Walter Leal Filho
Editor

CLIMATE CHANGE MANAGEMENT

Universities and Climate Change

Introducing Climate Change at University Programmes

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Foreword

It is widely acknowledged that universities can play a key role in helping to meet the various challenges posed by climate change. However, the means to do so are not always widely known, nor are there clear mechanisms via which matters related to climate change may be systematically included in university programmes. Part of the problem is due to the complexity which is inherent to climate change, but part of it is also due to the "tunnel vision" of many higher education institutions, which limits the handling of climate matters to a few subjects, without taking into account the whole picture.

Yet much could be gained by giving a proper and broader consideration to climate issues in university degrees, extension courses and projects at universities. No matter if we are speaking about global warming, sea level rise, anthropogenic or naturally induced climate change, there is a pressing need to properly inform and educate university students, so as to allow them to understand not only the direct facts and phenomena which are related to climate change, but also their social, economic and environmental impacts.

Overall, universities may help to foster a broader understanding of the challenges of climate change by:

- providing more adequate teaching programmes vis-à-vis the proper inclusion of matters related to climate change in teaching, beyond the traditional, technical subjects;
- ensuring a stronger emphasis on applied research into climate change which integrates technical issues with social and economic ones, hence opening up the way for a holistic understanding of the problem and its ramifications;
- fostering deeper involvement from students in the process of understanding climate change, from campus-based initiatives to the organization of climate-friendly events so as to allow universities to practice what they preach.

This book fills a long-standing gap in publications specifically focusing on the means via which climate change at university level may become a reality. It does so by listing various initiatives being undertaken at universities all around the world, as well as by describing practical projects performed by a number of universities. By means of a combination of elements related to curriculum design, research methods, projects and case studies, it provides a unique overview of the subject matter of climate change at universities and describes some of the ongoing efforts to give it a more prominent position in university programmes.

Prepared in the context of the International Climate Change Information Programme (ICCIP), led by the Hamburg University of Applied Sciences, this publication will be very useful to all those interested in the handling of matters related to climate change at university level and in fostering a holistic awareness among students and staff about the meaning of and the need for a proper emphasis on climate change at universities.

Hamburg,
Winter 2009/2010 Prof. Walter Leal Filho

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Chapter 1
Climate Change at Universities: Results of a World Survey

Walter Leal Filho

Abstract This chapter presents an analysis of the extent to which climate change is being dealt with in the context of university programmes. It also describes the methodology used and the results obtained from the "World Climate Change Survey", a research initiative aimed at identifying the general level of awareness of and needs of university students about climate change in university programmes worldwide. The survey was specifically targeted at university students so that first-hand information on current practice can be gathered and reality-based suggestions can be made to address the identified problems and needs.

Keywords Curriculum · Research · Survey · Training · Universities

Introduction

Climate change is not only a problem limited to meteorology or geophysics. It is among the most significant challenges facing society today. Whereas it was in the past an issue whose discussion was mostly performed by a limited number of scientists, awareness about its strong social, political and economic implications means that it has evolved to become an issue of central relevance to both science and politics.

Similar to what happened to sustainability education in the past, education about climate change has now become a top priority. Indeed, instead of being regarded separately, climate change education and sustainability education need to be seen as closely related, with climate change at the *micro level* being regarded as a *unit* of sustainability education at the *macro level*. Any improvement seen in respect of awareness about climate change automatically leads to an increase in awareness about sustainability, since most matters are intertwined. The impact of human activities on ecosystems and the control in emissions of greenhouse gases are, for example, two of the many items which need to be better understood if long-term solutions for the problems posed by climate change are to be found.

W.L. Filho (ed.), *Universities and Climate Change*,
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Even though climate change education is important to all education levels, from primary schools to universities, it is in the higher education sector that the need to tackle it in a systematic way is particularly acute. This is due to the fact that university students will soon pursue careers in science, education, law or engineering among others and hence need to be conscious of the impact their professions have both on the environment as a whole and on the climate in particular. The objectives of climate change education at university level are numerous. They include the following components:

- The development of a broader knowledge among university students about the basic principles of climate change and the degree of contribution provided by the natural sciences, social sciences, economics, architecture, arts, etc. towards both the understanding of climate change and the complexity of problem-solving approaches related to it.
- The education of university students in the socio-economic issues (e.g. poverty, social justice, security) associated with climate change and to which governments need to find a solution in order to ensure the survival of people and habitats.
- The motivation of students to take action both during their time as students and, later on, as professionals.

One of the special features of climate change education is the fact that it fosters a broad awareness of the historical evolution of the problem and how it will affect future developments and society. It is therefore a field of work where lessons from the past may be useful in identifying the sorts of action expected in the future. Figure 1 illustrates some of the abilities students need to develop in order to fully understand the complexity of climate change.

Awareness of the issues outlined in Fig. 1 (whose list is by no means exhaustive) is important in the development of climate change education initiatives and in fostering the action needed to put the principles of climate change education into action (Leal Filho 2009).

- Awareness of about the connections between global and local events
- Understanding of the impact of geophysical events on local communities
- Envisioning the need for global, regional and local action against climate change
- Understanding of the role of policies in the climate change problem-solving process
- Acceptance of the need for climate change governance
- Consciousness of the need for mitigation and adaptation measures
- Critical overview of situations and contexts which exacerbate the impact of climate change
- Distinction between the role of global institutions and national governments
- Use of mental processes to understand and interpret the causes and consequences of events related to or resulting from climate change
- Willingness to take action

Fig. 1 Abilities to be fostered among students in climate change education

Climate Change Education Initiatives at Universities

The value and relevance of sustainability initiatives as a whole, and on climate change education at universities in particular, is beyond dispute (UNESCO 1995; Breyman 1999; Foster 1999). In the specific case of climate change at universities, the literature refers to some works aimed at fostering this field, such as the book by Eagan et al (2008) on higher education in a warming world, and Rappaport and Creighton (2007) who, by means of "Degrees that Matter: Climate Change and the University", drew attention to the problem.

One example of an international initiative on climate change education was the "European Climate Teach-In Day" organized by the Hamburg University of Applied Sciences within the context of the International Climate Change Information Programme (IICIP). The "European Climate Teach-In Day" was held on *5 June 2009*, which is also World Environment Day, a key date in the world environment calendar. The aims of the "European Climate Teach-in Day" were:

- To disseminate scientific information on climate change in a way that allows it to be broadly understood, including elements related to its environmental, social, economic and policy aspects to schools and universities around Europe
- To raise awareness among secondary school and university students on the complexity of matters related to climate change and the need for personal engagement and action
- To provide an opportunity to introduce projects and other initiatives being undertaken at the international but also at the regional and local level by schools, universities, government bodies, NGOs and other stakeholders
- To discuss the problems, barriers, challenges and opportunities and potential related to climate change both at the local and regional level, but also globally

Last but not least, the "European Climate Teach-In Day" was meant to encourage more networking and information exchange among participants and hopefully catalyse cooperation initiatives and possibly new projects. Figure 2 offers a screenshot of the event's website.

The initiative was a great success: University lecturers and teachers from 265 institutions in more than 55 countries used the opportunity to download the climate content provided in the framework of the event. Over 12,000 students from universities and schools were involved in the initiative.

The World Climate Change Survey: Methodology of the Study

Even though much has been written about climate change as well as climate change education, there is a shortage of empirical studies which aim to understand how climate change is seen and perceived among university students. Therefore, a survey about climate change among university students would seem an effective

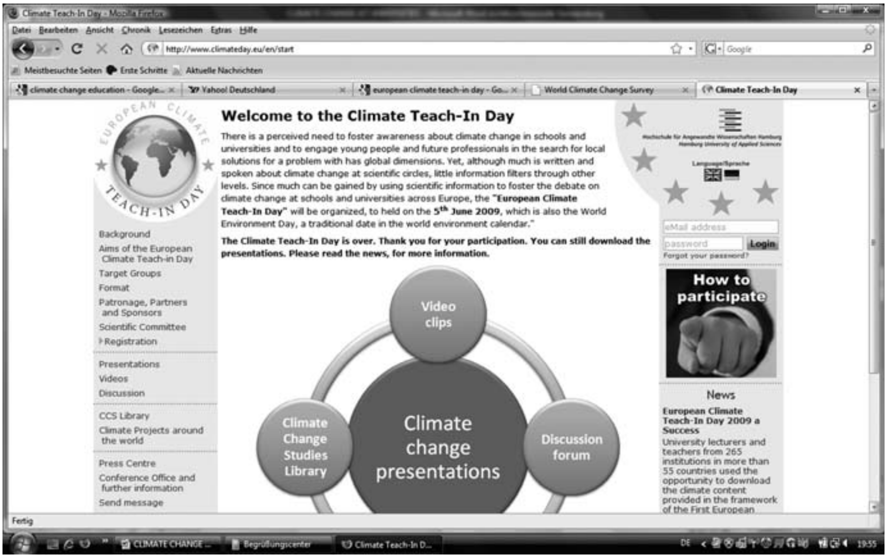

Fig. 2 Site of the European climate teach-in day
Source: http://www.climateday.eu/en/start

way to analyse current trends, identify possible problems and propose some possible solutions.

From a methodological perspective, surveys have for many years been used to assess attitudes and characteristics of a wide range of subjects from opinions about services to the identification of habits. But it is noticeable that the variety and scope of survey research has experienced many changes over the past 30 years, both with respect to design (Schuman and Presser 1981; Sudman and Bradburn 1982; Schafer and Rogers 2003) and applications (e.g. Lipps 2008), as well as with respect to data collection (Forsyth et al 1992). There is at present a wide range of survey tools being used, which vary from automated telephone surveys which use random dialling methods, to computerized kiosks in public places (e.g. theatres, bars, cinemas) which seek to gather people's input. Surveys can also be performed as part of project work in order to gather data (e.g. Bennett 1996; Leal Filho et al 2000; Leal Filho and Manolas 2004). In addition, surveys can also be directed towards gathering input needed for the delivery of services such as car hire, flights, hotel or restaurants, in which case the survey focuses on the opinions of users.

In a step-by-step guide, Salant and Dillman (1994) provide a number of tools that one should consider in a survey, such as:

- Determine which type of survey is best for you
- Estimate the cost of your survey

- Conduct mail, telephone, and face-to-face surveys
- Draw accurate samples
- Write effective questionnaires
- Compile and report results
- Avoid common survey errors
- Find reliable outside assistance
- Salant and Dillman (1994)

With the advancement of technology, surveys may now be undertaken electronically and this has led to many interesting developments and to a wider use of surveys as a whole. Electronic or online surveys have developed considerable in the past ten years or so, with a substantial contribution being provided by Dillman (1999) with a compendium of email and Internet surveys. Works written by Schonlau et al (2007) on attitudinal questions on web surveys and by Potaka (2008) on the design of Internet forms, provide further evidence of the usefulness of Internet surveys as research tools as well as the various elements that need to be considered in using them.

In order to allow an assessment of the general level of awareness of and needs of university students about climate change in university programmes, the "World Climate Change Survey" was performed. This was meant as a research initiative targeted at university students from around the world so that first-hand information on current practice could be gathered and reality-based suggestions could be made in order to address any identified problems or needs.

The technique used in this study, namely a *questionnaire-based Internet survey*, is a relatively new modality of performing survey work and a format whose use could not be easily undertaken 20 years ago due to the rather limited use and access to Internet and web-based technology at the time. Indeed, in the past, mail questionnaires were the most intensively used method of conducting surveys in places away from the researcher and were sent to the respondents via either surface or air mail. Mail questionnaires had the main advantage of being inexpensive. In addition, they could also include pictures and allowed respondents to complete them in their own time. Mail questionnaires have however some disadvantages, one of which is the fact that it may take considerable amounts of time to collect the responses. Moreover, response rates are often rather low and their use could lead to biased sampling since researchers do not always know the background of the respondents well.

Although in the past many questionnaire surveys have been carried out by post (e.g. Leal Filho et al 2000; Leal Filho and Manolas 2004; Leal Filho and Faisal 2004), it is believed that greater savings in both time and costs can be achieved if the Internet can be used. Dillman (1999) has described the advantages related to mail and Internet surveys, whilst in a work undertaken for the US Federal Committee on Statistical Methodology, Schafer and Rogers (2003) described the many advantages of data collection using web services.

Internet surveying needs to be compared with any other survey project, which means it needs to have sound planning behind it (Berkun 2005). Technically, it can be regarded as a descriptive research method. Surveys are techniques widely recognized as useful when a researcher intends to collect data on facts and phenomena which cannot be directly observed (i.e. opinions, levels of information or attitudes) and this fits well with the thinking behind Internet surveys. In general terms, Internet surveys provide the following advantages:

- Geographical distance does not matter
- They are relatively inexpensive to conduct
- If properly designed they may offer a user-friendly interface and motivate responses
- The same instrument can be sent to a large number of people

In addition, Internet surveys allow respondents to fill in questionnaires at their own convenience. But there are some disadvantages as well. For example, response rates from Internet surveys are often very low since many people may confuse them with spam. Also, Internet-based questionnaires are not the best vehicles for asking for detailed written responses.

A SWOT analysis of Internet surveys reveals that they have some weaknesses and threats, which represent some real limitations. However, the analysis also shows that some interesting opportunities exist (Table 1).

In respect of the work performed as part of the "World Climate Change Survey", the intention was to find a reliable way to cater for data collection from different countries within various geographical regions. Methodologically speaking, the emphasis of this study was on qualitative aspects. Consistent with this, the approach used consisted primarily of non-numerical measurements, with a focus on the frequency of responses given to the questions asked.

There have been a few past and ongoing studies on climate change performed at universities such as:

Table 1 SWOT analysis of Internet surveys

Strengths	Weaknesses
Inexpensive to run	Not all respondents may provide accurate information
Allows data from various countries to be collected	Limited control of who will take part
Use is internationally accepted and regarded as valid	Lack of interaction with respondents
A track record of success exists	Requires Internet access
Opportunities	**Threats**
The infrastructure is often available	Competition with various other surveys
Detailed IT support is not needed	Lack of familiarity among some respondents with the completion of surveys
Respondents can complete the survey in their own time	Respondents may be distracted and do not reply accordingly
Possibilities for including open-ended and multiple-choice questions	Respondents may answer the survey more than once

- The Global Climate Change Survey at the University of New Mexico (http://www.unm.edu/~rberrens/gcc/)
- The MIT survey on climate change concerns (http://web.mit.edu/newsoffice/2006/survey.html)
- Penn State's Survey on Climate Change Values (http://pennstatefocusthenation.org/survey/) or
- Virginia State Climate Change Survey (http://millercenter.org/academic/gage/panel/detail/4051)

Little research has been done so far on the handling of climate change specifically in the context of university programmes and no surveys have ever been performed with a focus on the assessment of the degree to which climate change is dealt with in universities across the world. This demonstrates the existence of a research and information gap that needs to be addressed.

The World Climate Change Survey also aimed to point out any information and communication needs that exist and that should be met in order to allow a better integration of climate-related issues in the university curriculum across the world. In order to cater for a wide participation, the survey was performed by means of an easily accessible website. Figure 3 provides a screenshot of the website of the survey.

For practical purposes, the survey instrument contained multiple-choice questions but respondents were also able to provide additional information if they so wished. On occasions, the survey instrument was sent by email to respondents, who

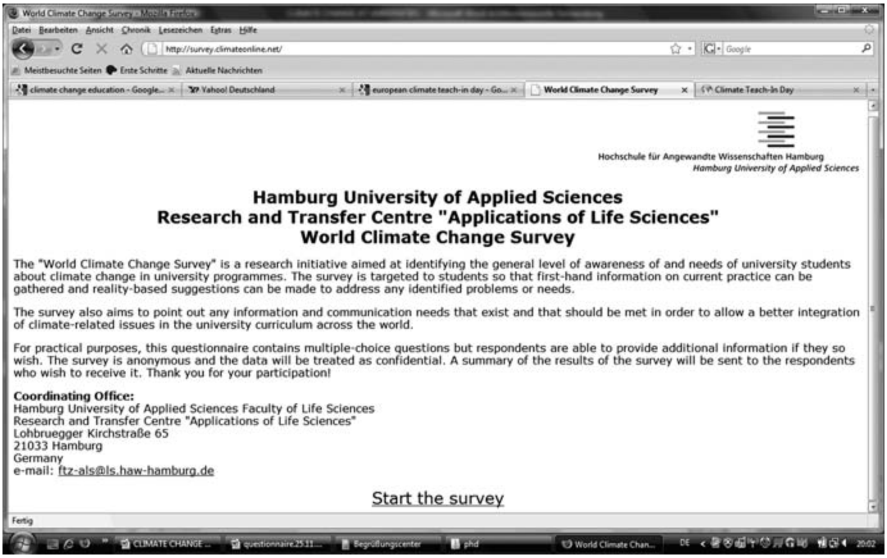

Fig. 3 Homepage of the survey
Source: http://survey.climateonline.net

would fill in the form and also return via email. The survey was performed over a period of 6 months, between January and July 2009. It was anonymous and the data was treated as confidential. As a courtesy to the respondents, a summary of the results of the survey was to be sent to those who expressed an interest in being informed of the results.

Results and Discussion

In general terms, 1,250 students from 166 universities in 43 countries took part in the survey. These form the basis for the analysis of the results obtained. For practical reasons, the results will be presented and analysed at the same time. As a whole, universal findings will be presented. On occasions, significant regional differences are specifically discussed. Due to space restrictions, distributions of findings per region or cross-references of findings will be outlined in other publications.

The first part of the questionnaire gathered some general information about the respondents. From the total replies obtained, it can be seen that 43% of the respondents were female and 57% were male. The distribution of the respondents by age groups is as follows:

- 18–22 years old: 32%
- 23–26 years old: 59%
- 27 years old or more: 9%

As to the countries of origin of the respondents, these were distributed across 47 nations in the following continents:

- Europe: 53%
- North America: 21%
- Latin America: 9%
- Africa: 5%
- Australasia: 12%

It can be seen that European countries were very well represented, whilst the participation of universities in Africa and Latin America was much lower. This could be the result of the lower degree of Internet access in Africa and Latin America and perhaps the limited dissemination of the survey in these regions. These are coupled with the fact that the survey was performed in English and no translations into other languages were provided.

Regarding the course/programme that respondents were studying at the time, Fig. 4 presents the distribution of the findings. The item "Others" relates to courses such as "philosophy" which were specifically named.

It can be seen that the majority of the students were pursuing courses of study in the social and natural sciences, while engineering came in third place. Proportionally fewer respondents are from the field of computer science/IT.

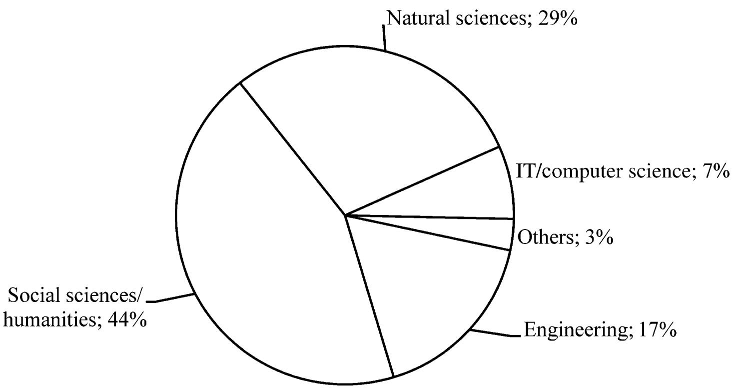

Fig. 4 Courses/programmes attended by the respondents

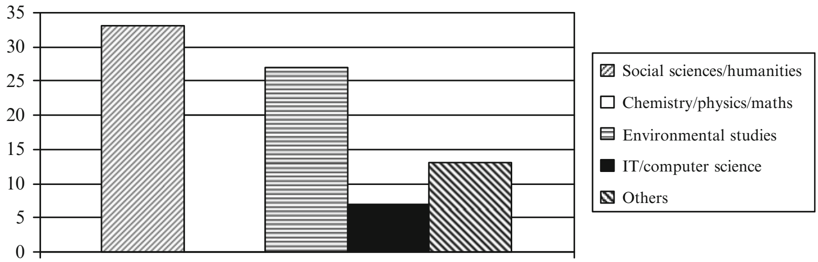

Fig. 5 Main disciplines taught

Table 2 Students' interpretation of what climate change is

Opinion	Frequency of replies (%)
It means the world's climate is changing	62
It means the ice in some areas will melt	57
It means more rains/droughts may be expected	52
It means increases in global temperatures	47
It means in some areas more storms are expected	42
It means the sea level may rise	53

In respect of the year of the programme they were in, 32% of the students were in the first year of their studies, whilst 11% were on the second and 16% were in the third year. Students attending the fourth year accounted for 27% of the sample, whilst students attending Masters courses made up 14% of the sample. The main disciplines taught in their courses and programmes are outlined in Fig. 5.

Other responses, which accounted for 13% of the total, include geology, politics, international relations, policy and agriculture to name a few.

The survey also aimed at enquiring about respondents' views about what climate change is. The results are summarized in Table 2 (multiple answers were possible).

It can be seen that the respondents have a fairly structured interpretation of what climate change means.

Other meanings mentioned included:

- Climate change also means controversies between scientists, climate package, political problems
- Increased suffering of the people living in developing countries of Asia and Africa
- The natural variation in Earth's climate, most likely recently exacerbated by human activities
- Loss of charismatic species, greater spread of insect-born diseases to higher latitudes, increased number of human deaths from heatwaves, storms, and disease
- It implies all the various effects of a changing climate on humans, animals, biodiversity, etc. The roots of climate change are man-made, which is what makes it so difficult to find out what changes in nature are normal and which are caused by climate change

The levels of responses obtained indicate that students' views of what climate change is and what it entails are fairly accurate.

One further question asked in the context of the survey was the main sources of information among students on climate change (multiple answers were possible). Table 3 shows the responses obtained and a breakdown of answers by continent.

Table 3 illustrates the fact that although the media is the predominant source of information about climate change in all surveyed regions, there are differences seen in respect of the role played by universities as sources of information. Only in Africa were universities perceived as being consulted for information more often than the Internet, which is regarded as major source of information to over 80% of the sample in North America. Elsewhere, the information provided by the media and the Internet seems to outweigh the level of information provided by universities. In addition, in Africa and Latin America, the family seems to be an important source of information when compared to other regions.

Other information sources mentioned were academic books, journals, conferences and seminars, NGOs, charities and religious organizations.

When asked whether climate change appeared as a subject/topic in their courses and teaching programmes, respondents provided different levels of responses. As

Table 3 Sources of information on climate change among university students

Source	Europe (%)	Africa (%)	Asia/Oceania (%)	Latin America (%)	North America (%)
Media (TV, newspapers, radio, etc.)	63	54	44	67	71
University courses	42	32	22	54	68
Internet	54	29	35	56	82
Family	12	22	11	23	7
Friends	32	18	20	19	12
Clubs/associations	29	11	31	4	21
Others	5	6	4	7	9

Table 4 Presence of climate change as a topic/subject in courses/teaching programmes

	Europe (%)	Africa (%)	Asia/Oceania (%)	Latin America (%)	North America (%)
YES	71	43	59	61	83
NO	29	57	41	39	17

seen in Table 4, climate change is prominently featured as part of courses in North America and Europe, with a lower level of emphasis in universities in Latin America and Asia/Oceania. Interestingly, climate change as a teaching topic seems to appear in less than half of the surveyed universities in Africa.

The question as to which subject(s) have so far closely tackled matters related to climate change (multiple answers were possible) as part of their teaching programes produced the following level of replies:

- Natural sciences (e.g. biology, physics, chemistry, etc): 73%
- Social sciences (e.g. economics, politics, etc): 68%
- Humanities (e.g. history, ethics, etc): 21%
- Engineering sciences (e.g. maths, statistics, processing, etc): 44%
- Arts/Design or entertainment: 12%
- Sports/Leisure: 4%
- Others: 9%

It can be seen that, overall, the sample seems to indicate that climate change matters are mostly taught in the framework of the natural and social sciences, with a lesser emphasis in engineering. There seems to be room for improvement in respect of the emphasis given to the human dimensions of climate change, since less than a quarter of the students mentioned humanities as being among the subjects within the context of which climate issues are approached at universities. A degree of deficiency is also seen in the level of emphasis given to climate issues in the context of the arts and sport/leisure courses.

Other subjects areas mentioned were planning, management, forestry and agriculture, among others.

In order to allow a better understanding of the current level of emphasis to matters related to climate change given at universities at present, students were asked to rank their opinion from a Likert scale (i.e. from 1 to 5, with 1 being the highest and 5 the lowest ranking given). The results are summarized in Table 5, which distributes the responses among the various geographical regions.

Data amassed in Table 5 indicates that significant room for improvement exists regarding the coverage of climate change issues at universities. It is of great concern that over half of the respondents in Africa and nearly half of the respondents in Latin America think that climate change is poorly covered or not covered at all in university programmes. In addition, nearly half of the surveyed students in Europe believe that climate change is not as well covered as they expect – a line of thinking seen in over 40% of the sample in North America. Despite these differences, the Likert scale used to rank the opinion of the surveyed students about the importance of knowledge about climate change to their studies shows the following trends.

Table 5 Level of emphasis to matters related to climate change according to the sample

Scale	Europe (%)	Africa (%)	Asia/ Oceania (%)	Latin America (%)	North America (%)
1. The topic is very well covered with plenty of information	13	9	8	11	17
2. The topic is covered with enough information	21	14	23	17	27
3. The topic is not as well covered as we would like it to be	43	20	34	32	41
4. The topic is poorly covered	12	33	10	22	7
5. The topic is not covered at all	9	19	19	17	6
6. I do not know/am not sure	2	5	6	1	2

Table 6 Opinion of students on the usefulness of knowledge of climate change

Scale/Opinion	Strongly disagree (%)	Disagree (%)	Agree (%)	Strongly agree (%)
It will be helpful in meeting my own information needs	2	4	20	74
It will be helpful in influencing my lifestyle	3	7	29	61
It will be helpful when I try to find a job	5	10	38	47
It will be helpful in giving me a better understanding of the world	8	12	28	52

- Scale 1: The topic is essential to my studies: 32%
- Scale 2: The topic is very important to my studies: 24%
- Scale 3: The topic is important to my studies: 14%
- Scale 4: The topic has a moderate importance to my studies: 21%
- Scale 5: The topic is not important to my studies: 6%

Only 3% of the students have stated they do not know or that they are not sure.

When asked what the emphasis on climate change in their university programmes will be in the *next two years*, 62% of the respondents believe it will increase, 26% believe that the emphasis will remain the same, 4% stated that the emphasis will decrease and 8% stated they do not know or are not sure.

Students were also asked their opinion as to whether a better level of knowledge of matters related to climate change may be useful to them now and in the future. The results are presented in Table 6. It is noticeable that the majority of the respondents confirm the usefulness of knowledge about climate change issues for meeting their information needs and for their own lifestyles. In addition, over half of the respondents acknowledged that knowledge about matters related to climate change may be useful in their professional development.

In respect of the environmental and problems they see as a result of climate change, the replies from the respondents are summarised in Fig. 6 as follows (multiple answers possible):

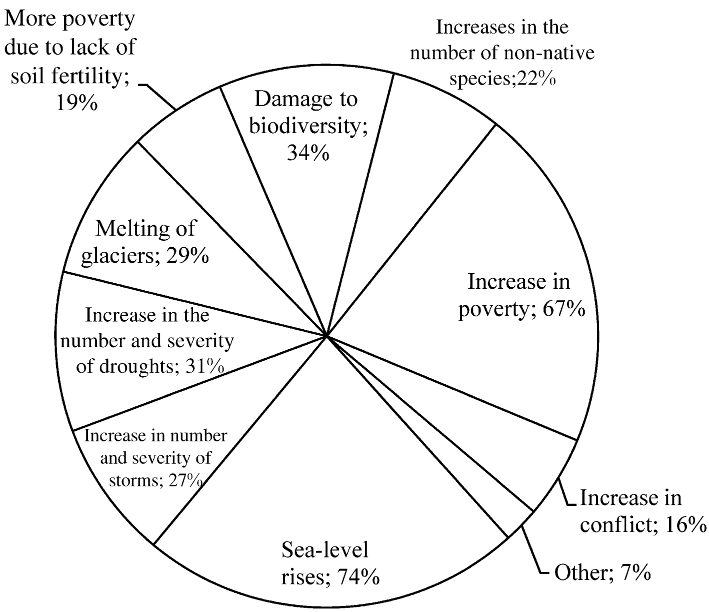

Fig. 6 Problems connected with climate change

Examples of other problems mentioned were the risks of wars, increase in the risk of diseases, depletion of the ozone layer and hotter summers and colder winters among others.

The surveyed students were also asked to list the effects they think may be related to climate change. Their replies (multiple answers possible) were as follows:

- Financial: 32%
- Social: 47%
- Ecological/Biological: 59%
- Physical: 32%
- Chemical: 27%
- Political: 19%
- Other: 6%

Other effects listed were related to items such as health problems, an increase in migration, food shortages and social conflicts among others.

When asked about their opinion of the main problems hindering communication and/or learning about climate change (multiple answers were possible), respondents provided a wide range of responses, which are summarised in Fig. 7.

The impressions gathered from the sample seem to indicate that the complexity of the subject of climate change and the fact that it is rather scientific are among the main factors which make climate change communication rather complicated.

In order to allow an assessment of whether enough emphasis is being placed on climate change at their university, the respondents were asked to rank their

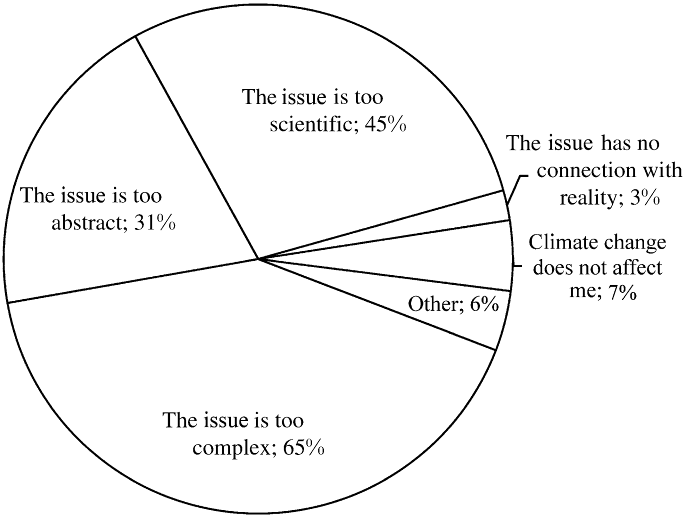

Fig. 7 Problems that hinder communication on climate change

opinion about the different levels of emphasis given to it at universities. For practical purposes, priority in the data analysis was given to the areas where *too little emphasis* is given (thus showing clear deficiencies). These were prioritized in order to offer guidance about what needs to be done to address them. The results are as follows:

- In the field of *minor university courses* (e.g. complementary courses), 42% of the African students and 37% of the Latin American ones specified the fact that too little emphasis is provided at this level, complemented by 25% of the sample in Asia/Oceania. European (21%) and North American (18%) students also feel that too little emphasis is provided.
- As far as the emphasis on climate change issues in *majoring university courses* (e.g. essential courses related to a certain degree) are concerned, little emphasis was a fact mentioned by 72% of the African students, followed by 66% of the sampled Latin American students and 52% of the students in Asia/Oceania. In terms of students in North America, 32% of the students said that there is little emphasis in majoring courses, followed closely by 29% of the European students.
- *Research* on climate change is important at universities. However, the fact that little emphasis is given to it was referred to by 67% the sample in Africa, 56% of the Asian/Oceanian sample, 49% of the Latin American sample, 39% of the North American and 31% of the European sample. This indicates that in a developing country context, research on climate change is yet to find its way into university programmes.
- The low degree of emphasis on climate change in *campus activities* seems to be a worldwide problem. Nearly 90% of the African sample, 79% of the sample of

Latin American students and 68% of the sample of students from Asia/Oceania stated that this area has been largely overlooked. A significant number of European students (51%) have stated that there is little emphasis on climate issues in campus programmes, a trend which is slightly better in North America, where 38% of the sample stated that this is a problem.

– Attempts to make *climate events neutral* are at an embryonic stage in Africa and Latin America, where over 80% of the sample said this area has had little emphasis. Trends are a little better in Asia/Oceania (71%). European students (42%) and North American ones (29%) have stated this area has little emphasis, which suggests that the climate impact of events (e.g. seminars, conferences) is receiving some attention.

The existence of climate change as a topic in *exams* is widely regarded as a rare trend. Except in North America, over half of sample in the rest of the world stated that this is an action seldom seen. In other words: climate change is not often regarded as an exam-relevant topic. If this remains so, it is unlikely to become mainstream since exams are central to university degrees and issues which are relevant to exams traditionally receive more attention.

In respect of the aspect(s) of climate change which interest them most, students replied as follows:

- Technical aspects (e.g. Modelling/scenario): 32%
- Economic aspects: 47%
- Ecological/environmental aspects: 56%
- Social aspects: 61%
- Political aspects: 22%
- Ethical aspects: 12%
- Educational aspects: 29%
- Other: 4%

These figures show that the social and ecological aspects of climate change are deemed as very interesting, along with economical issues, technical aspects and the educational ones. Comparatively little interest was seen in respect of ethical aspects.

When asked if they are happy with their current level of access to materials/publications on climate change (e.g. official reports, books, bulletins, magazines), respondents provided different levels of responses. The frequency of positive replies provided by the sample of respondents – i.e. the number of respondents who are happy with their levels of access is as follows:

- Africa: 17%
- Asia/Oceania: 31%
- North America: 37%
- Latin America: 21%
- Europe: 29%

This indicates that among African students, less than 20% are happy with their current level of access, whilst in Latin America it is just over 20%. Meanwhile, less

Table 7 Students' views on what can be done to improve communication on climate change

Scale/Opinion	Strongly disagree (%)	Disagree (%)	Undecided (%)	Agree (%)	Strongly agree (%)
More emphasis in university courses	2	4	8	28	58
More coverage by the media (quantitative)	3	8	6	34	49
Better coverage by the media (qualitative)	3	11	14	32	40
More participation of teaching staff/ professors in research/teaching projects	1	9	21	32	37

than 30% of the European and under 40% of the North American students are satisfied with their level of access to climate change information.

A further question which can be referred to in this chapter asked students to specify what they think needs to be done in order to allow a better communication of matters related to climate change. The results are summarized in Table 7.

The question as to whether students are satisfied with their level of knowledge on climate change produced the following results:

- Fully satisfied: 32%
- Partly satisfied: 29%
- Undecided: 19%
- Not really satisfied: 13%
- Not at all: 7%

The final question asked students to state where more information from within their universities, about climate change should come from. Figure 8 summarises the results (multiple answers possible).

It can be assumed that mandatory courses and placements in companies are the most popular means to obtain information. Optional courses and projects also offer very good opportunities for addressing climate change matters at universities.

Conclusions: Implications for the Curriculum at Universities

Despite the constraints in the execution of the survey and the fact that the conclusions drawn from it are limited to the sampled students, some interesting trends have been identified and a number of conclusions can be drawn. The first element worth mentioning is the fact that the sampled students have a fairly realistic view of what climate change is and means. Their view also takes into account the fact that, over and above the usual items, climate change may also entail controversial matters, and has an impact on human beings and ecosystems.

A second element worth mentioning is related to the sources of information on climate change. According to the sample, the media is a very important source, but

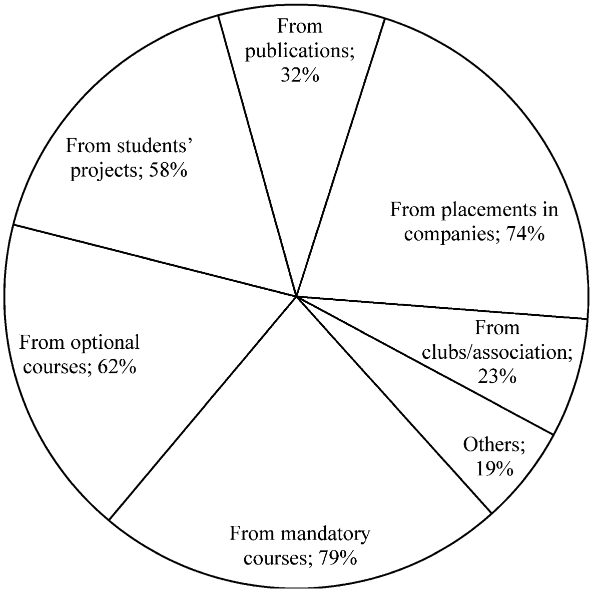

Fig. 8 Students' opinions on preferable information sources on climate change

the emphasis given to climate matters at university programmes in North America (with 68% of the replies) and Latin America (56%) is an encouraging trend. The Internet also plays an important role as a source of information on climate issues. Clubs and associations are also deemed important sources of information in Asia/ Oceania and in Europe.

The presence of climate change as a topic in study courses and programmes in most regions all over the world seems to be a real trend, but one which needs to be seen in a differentiated manner. In Africa, for example, over half of the sample stated that such programmes are absent. In addition, climate issues are predominantly approached in the context of natural and social sciences and – to a lesser extent – in other subjects. In terms of emphasis on climate change at universities, the respondents indicated that the frequency of occasions where the topic is either not well covered and poorly covered is rather high. This state of affairs indicates that action is needed so as to bring the levels of coverage of climate matters at universities to a more satisfactory level. This seems an essential step when one takes into account the fact that over 60% of the sampled students regard climate change as either essential or very important to their studies and they feel that emphasis on climate issues will increase in the future.

There seems to be little doubt left in respect of the usefulness of climate change as a subject matter to students, since over 70% referred to it as important for their information needs and nearly half of the sample stated that the topic is important for their careers.

The survey also outlined the fact that there are some concrete problems related to the implementation of climate change programmes at universities. First of all, it is clear that the fact the topic is regarded as too complex or too abstract poses a problem. There is also a pressing need to make climate change more present in majoring and minor areas and in campus activities, since universities need to practise what they preach. The inclusion of climate matters in exams may be one way of positioning it more prominently in university courses, whilst the organization of climate-friendly events may also help to raise more awareness at university level.

In terms of designing future strategies to introduce climate change programmes to university curricula, the survey has established that ecological, social and economic aspects deserve a special emphasis and need to be considered, instead of a focus on technical aspects as has traditionally been the case. Since most students are unhappy with the level of information available to them on climate change, this step may be an important one. Indeed, the greater inclusion of climate matters on university courses was regarded as important by over half of the sample.

Finally, it is important that mandatory courses and optional courses strive to make more provisions for tackling climate change issues and that climate topics take a more prominent role in students' projects.

The World Climate Change Survey has established that, for various reasons, climate change as a topic deserves proper attention and needs to be taken more seriously by universities. It can no longer be regarded as a domain of meteorologists or physicists as has largely been the case in the past. Instead, its deep social, economic and social roots means that climate change needs to find its way across all relevant parts of university programmes.

There are many factors which speak for the inclusion of matters related to climate change at universities. These vary from the sheer need to properly inform and educate students, to the pressing need to train them to address what is one of the greatest challenges of modern times.

However, if it is to be properly included in university programmes, then it is necessary to address the deficiencies outlined here and provide a solid basis upon which climate issues may be positioned more prominently in teaching and research programmes in universities across the world.

In order to help to raise the profile of climate change at universities and as a follow-up to the successful "European Climate Teach-In Day", a set of regional "climate teach-in" events will be organized, under the auspices of the "International Climate Change Information Programme" (ICCIP) and in cooperation with partner universities around the world. These events will have a regional dimension in the sense that universities from a geographical region (and not from one single country) will be able to take part. The ones planned to date are:

- The "World Climate Teach-In Day"
- The "Asian/Oceania Climate Teach-In Day"
- The "African Climate Teach-In Day"
- The "Caribbean Climate Teach-In Day"
- The "Latin American Climate Teach-In Day"

These activities will be repeated periodically and will serve the purpose of engaging more universities with the issue of climate change and help to disseminate the good work and projects performed by university staff in these regions. Ultimately, they will help to provide a basis upon which long-term awareness about climate change can be (continuously) raised. Last but not least, support towards the training of a cadre of well-informed professionals will be provided.

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Chapter 2
Path to the Future for Climate Change Education: A University Project Approach

Maruf Sanni, James O. Adejuwon, Idowu Ologeh, and William O. Siyanbola

Abstract The university system can be perceived as an institution that nurtures, trains, educates and monitors students in the understanding of myriads of bodies of knowledge about the earth's system and all other natural and human activities. With particular reference to climate change education, it also engages students in research activities as a way of learning science, understanding climate change, contributing to climate change studies and participating in several local and international workshops, seminars and conferences. This paper focuses on how climate change projects within the university system can be used to develop and build capacities in the field of climate science. The study develops a triadic model of capacity building built around training, mentoring and networking. A case study for the Assessments of Impacts and Adaptations to Climate Change (AIACC) project in sub-Saharan West Africa is used to illustrate this model. Considering the fact that many developed and developing countries are vulnerable to the impacts of climate change albeit with different intensities, it is recommended that these countries adopt this triadic model so as to increase capacity as well as reduce their level of vulnerability to impact from climate change.

Keywords Adaptation · AIACC · Climate change · Nigeria · Obafemi Awolowo University · Vulnerability

Introduction

Climate change is an issue for global discussion and it is fast becoming a subject which permeates every aspect of human lives. The new growth path of CO_2 emissions and global economic meltdown in both developed and developing countries is not helping the matter either. For instance, energy use and CO_2 emissions continue to increase in countries like the United States (US), China and India through their heavy reliance on coal and their energy needs (Sheehan 2008).

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The information from the US Department of Energy's Energy Information Agency for the USA puts the projection of energy use and CO_2 emission from fuel combustion at 1.1% and 1.2% per annum from 2005 to 2030 respectively, with energy use and emissions from coal use both growing at 1.6% per annum (DOE 2001/2007). A similar trend can be identified in key developing countries like China and India where coal constituted 71% and 55% of the total primary energy supply (excluding biomass and waste) in 2004 (IEA 2006a). The big coal plants which are currently being built in Germany can only add to the present challenges of climate protection (Meinshausen and Hare 2008). However, research efforts over the years and new commitments made by the Group of Eight (G8) may help improve our understanding of some of the complexities and technicalities involved in the science of climate change in the near future. The improvements made with respect to the strategies to adapt and mitigate the impact of climate change on social, political and economic developments should also be useful. As a result of these highly focused research activities and new initiatives, we have been able to reduce a great number of uncertainties. The interdisciplinary research projects have also enabled us to identify the most cost-effective measures to mitigate climate change (European Commission, 2005). For instance, research focusing on science, technology and innovation has brightened the prospects for a low-carbon society and several climate-friendly technologies have sprung up. Moreover, the approval of economic stimulus packages that incorporate environmentally friendly research activities in some developed countries could lead to an increase in the number of green jobs created in these countries. Issues such as this have helped to contribute to global arguments about climate change studies as one of the most important environmental challenges of the 21st century.

This paper examines how university projects can contribute to climate change education development by strengthening the capacity to comprehend the complex relationship between the earth, atmosphere, ocean and the cryosphere. The university system can be conceived as an institution that nurtures, trains, educates and monitors students in the understanding of myriads of bodies of knowledge about the earth system and all other natural and human activities. Moreover, with particular reference to climate change education, it also engages students in research activities as a way of learning science, understanding climate change, contributing to climate change studies and participating in several local and international workshops, seminars and conferences. However, as important as study of climate change is, very few universities in the world have climate change as a distinct course of study at the undergraduate level.

It is now becoming increasingly clear that the primary factor responsible for the development and wealth of countries and individuals is intellectual capital (Pawowski 2004). The development of countries such as China, Japan and Singapore with little or no natural resources and the astronomical growth of giant corporations like Google, Microsoft, Cisco and Nokia lay credence to this fact. The rallying point for these nations and corporations is scientific research and generations of new knowledge, which university systems readily provide. This study elucidates the role of universities within the wider context of learning. It looks at a range of programme activities that support university project goals, including increasing students' participation in regional and international gatherings focused on the issues of climate change. Consistent with the aim of capacity development, the paper intends to explore new ways of strengthening students' capacities to contribute to climate change studies both at the local and international levels.

Capacity building is central to most international conventions such as the United Nations Framework Convention on Climate Change, especially among the developing countries. Capacity transcends the availability of potential in a particular area of expertise: It concerns the ability of the individual, institution or society to be able to solve a particular problem. Capacity can be regarded as the ability (of an individual, institution, or society as whole) to identify and solve a problem or problems while capacity development has been described as the processes of creating, mobilizing, utilizing, enhancing or upgrading, and converting skills/expertise, institutions and contexts for the greater good (Mugabe et al 2000).

This study lays emphasis on the fact that it is important to teach students to carry out objective assessments of evidence of climate change around their local environments as well as the global community. Students must also learn the process and steps of carrying out scientific research so as to generate objective explanations and understand human influence on the environment. It is within this context that we propose the use of university projects on climate change as a form of instructional programme for university students at all levels (undergraduates and postgraduates). At this juncture, it is important for the teacher also to understand the basic interrelationship between earth's systems. This will allow the students to appreciate the concepts and understand how hypotheses about climate change were made and also the necessity to reduce the impacts. This paper examines the case of the Assessments of Impacts and Adaptations to Climate Change (AIACC) project in sub-Saharan West Africa to illustrate the model that can be used to achieve this goal.

Climate Change Education: A Case Study from the AIACC Project

AIACC was developed as a global initiative in collaboration with the United Nations Environment Programme (UNEP)/World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC) and funded by the Global Environment Facility (GEF) to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. This initiative intends to achieve this by awarding collaborative research grants and giving training and technical support to developing countries. The focus of this initiative is to enhance the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations, and generate and communicate information useful for adaptation planning and action. The programme is to be the responsibility of UNEP and implemented jointly by SysTem for Analysis, Research and Training (START) and the Third World Academy of Sciences

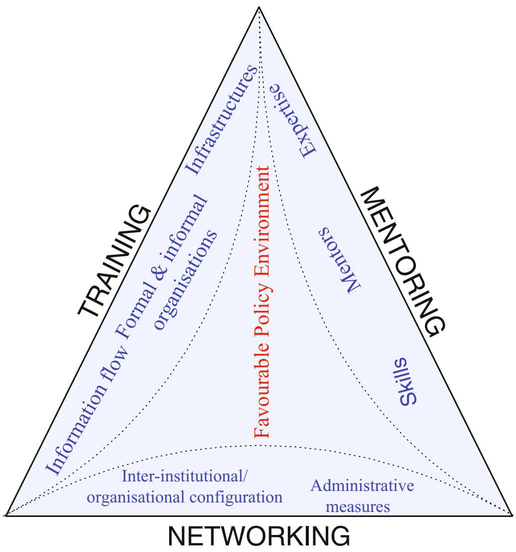

Fig. 1 A triadic model of capacity building

(TWAS). There is also a synergy between the GEF, the United States Agency for International Development, the Canadian International Development Agency, the United States Environmental Protection Agency, and the World Bank in terms of collateral funding. AIACC intends to fill the gaps which exist in understanding the nature of the vulnerability and opportunities for adaptation in developing countries. Also, another mandate of the organization is to improve scientific and technical capacity to conduct multidisciplinary regional research in the area of climate change. One of the most critical components of the AIACC capacity-building programme is the expertise that scientists will gain through participation in multidisciplinary research teams. The major components of this capacity building are training, mentoring, and networking. The paper intends to set out the proposed approach for climate change education on these three cardinal components, which will later result in a triadic model of capacity building (see Fig. 1).

Training

This component comprises the combination of formal and informal organizations, non-governmental organizations, information flow, financial incentives, and infrastructures. It is within the institution that the training of future experts will be done. In order for this training to have the desired impact, each of these elements must be properly structured. Within this component, seminars, workshops and conferences should be organized to teach the students the basic concepts of climate change. The institutions should invite international experts from international organizations such as the IPCC, GEF, UNEP and other non-governmental organizations to provide training on the methods and tools for assessing vulnerability and adaptation and constructing scenarios of climate and socioeconomic conditions. This training should be brought in at the third year for the undergraduate students and after the completion of coursework for the postgraduate students. The success of this training should be assessed by the level of understanding the students have of the basic concepts of climate change and the number of potential project titles that students are able to propose. Participants should also be able to state the scientific designs of their proposed projects. This gathering should also provide opportunities for participants to learn from each other. Another approach to training the students could also include active participation of the students in the field. This could be achieved by introducing the students to the local farmers who are most vulnerable to the impacts of climate change. Students should be encouraged to engage the farmers to discuss issues related to climate change with the intention of building the adaptive capabilities and resilience of the local farmers. During the discussions, the local, conventional and emerging technologies in terms of adaptation and mitigation techniques should be documented. It would also be necessary to set up experimental farms where documented techniques can be tested. However, before the techniques are tested, it is important that the experimental farms are selected based on certain parameters, such as income of the farmers, social status, age, etc. It is also important at this stage to include the other stakeholders (such as governments, agricultural input companies) in this process.

Mentoring

Another approach in strengthening capacity building in climate change studies is mentoring. This section describes the current expertise in climate change studies that could identify problems and provide solutions. The point of focus for this expertise and these skills is the individual in society. The goal of this component is to stimulate the interest of the students in the study of climate change. This can be achieved by inviting or linking the students with reputable scientists or policymakers who have an interest in the area of climate change. These mentors could also help the students plan and initiate their projects. The university should also provide students with a database of notable scientists in the field of climate change, which they can then choose from. Mentors from both developing and developed countries should be represented and should assist the students throughout the course of their projects. The mentors should guide students in areas such as the selection and application of data, sample size, methodology, models and scenarios for climate change studies. They should also attend to any other problems that may arise while the students are working on their projects. Mentors should also teach the students the art of publishing, most especially in peer-reviewed journals. Furthermore, mentors should also ensure that the students' projects under his/her supervision are published in reputable journals. Mentors should be able to open the eyes of the students to both local and international conferences and workshops where they can enhance their capacities.

Networking

Capacity development is time-dependent. Some societies may possess the skills today to enable them to solve a particular problem, but in a few years those skills may be inadequate for overcoming other, new challenges. As a result of this, there is the need to create a conducive policy environment where students can interact with the experts with ease. It is within this policy environment that the other two components would sit. This environment ensures a positive economic, political, sociocultural and general infrastructure, and a positive inter-institutional/organizational configuration, adequate policies, laws and administrative measures (Mugabe et al 2000). In order for the students to be able to interact with experts and other students from different locations with similar and diverse experiences, it is important to organize regional workshops in various locations such as Africa, Asia/Pacific and Latin America/Caribbean, the United Kingdom and the USA. These regional workshops could also bring together the project mentors and invite researchers and stakeholders from developing and developed countries to discuss current issues, techniques, and methodology for climate change studies. Participants and students should present papers from their research activities, mentors should share advice and collaborate with study teams to solve common problems, plan for joint publications with the students, and students should consult with mentors and other experts about their projects. To ensure sustainable networking, there should be a dedicated online discussion group where further interaction can take place. The dedicated online discussion group would bring together and strengthen regional networks of scientists and students who can collaborate and develop formidable teams in investigations of climate change.

A good example of this approach is that of the **A**sia-**P**acific **N**etwork for Global Change Research (APN). The APN is an intergovernmental network for the promotion of global change research and links between science and policymaking in the Asia-Pacific region. Members of this network include Australia, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Japan, Laos, People's Democratic Republic, Malaysia, Mongolia, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Russian Federation, Sri Lanka, Thailand, the USA, and Vietnam. However, what is lacking within this network is a dedicated online group discussion (where researchers can interact with students) and the absence of students' active participation. Another example of this model is the Climate Change Research Network at Vanderbilt. This network is very close to the model suggested in this study. It includes a team of faculty lecturers and graduate students who are conducting theoretical and applied research on climate change studies. The Climate Change Knowledge Network is another centre that brings together expertise, experience and perspectives from research institutes in developing and developed countries that are active in the area of climate change. It also provides a forum for rigorous research on the issues within the international climate change structure and a means for furthering dialogue between countries as they undertake efforts to address climate change. Again, active participation of both graduates and undergraduates is lacking.

Capacity Building Operations of the AIACC

There are several initiatives that examine the impacts of earth systems on climate change and their vulnerabilities to it. One such initiative is the AIACC. This global initiative was developed in collaboration with the UNEP/WMO IPCC and funded by the GEF to advance scientific understanding of climate change vulnerabilities and adaptation. It focuses mainly on the developing countries. The operations of the initiative allow for the funding of collaborative research, training and technical support. By so doing, it enhances the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations, and generate and communicate information useful for adaptation planning and action (Adejuwon 2006). In other words, its main contribution to the global body of knowledge is filling the gaps in scientific knowledge and capacity by funding, training, and mentoring researchers in the developing countries to carry out multi-sector, multi-country research of their own designs (Leary and Kulkarni 2007).

The AIACC project is one of the focal climate change activities of the GEF. The GEF was the primary source of funding for the AIACC project with a grant of US $7,500,000. Other grants came from the Canadian International Development Agency (US $100,000), the Rockefeller Foundation (US $25,000), the United States Agency for International Development (US $300,000), the United States Environmental Protection Agency (US $50,000) and the participating developing country institutions (valued at US $1,800,000) (Leary and Kulkarni 2007).

The organization has provided financial support to 24 regional study teams, 46 developing countries, 235 developing country scientists and more than 60 graduate and undergraduate students to conduct three-year investigations of climate change impacts, adaptation and vulnerability. More than 25 Masters and PhD theses that received support through participation in AIACC regional assessments were completed (Leary and Kulkarni 2007). The focus of the research activities in these countries are vulnerabilities to climate change, stresses, their implications for human development, and policy options for mitigating the adverse impacts. The array of information, knowledge, tools, and skills generated by the research activities has enhanced the ability of the scientists to assess many countries' vulnerabilities and adaptation options. This model of capacity building is close to the model suggested in this study. However, in terms of students' participation, students' share ratio and level of active participation is very low. Consideration of this minor observation will make this model one of the most appropriate methods for capacity building for students with a focus on climate change studies. This method of capacity building is purely research-driven, and can be complemented by the other three cardinal components of capacity building: training, mentoring and networking. The engagement of stakeholders in the vulnerability assessment process has further strengthened the information base for policymakers to make informed decisions about adaptation to climate change in these countries.

The success of these assessment projects has produced over 60 papers in peer-reviewed journals and books and over 40 papers in the online peer-reviewed *AIACC Working Papers* series. In terms of student participation, there were more than 25 student theses (Leary and Kulkarni 2007). Another indicator of the success stories of the assessments is the number of citations in the recent IPCC 4th Assessment Reports and contribution to the national communications to the United Nations Framework Convention on Climate Change (UNFCCC).

Due to the multidisciplinary nature of the AIACC projects, many scientists have been able to create networks across disciplines, institutions, and countries. These networks have resulted in collaboration that could yield further research investigations. Since most of the AIACC workshops engage the stakeholders, their involvement has resulted in important inter-country collaborations in the area of climate change studies, such as the ones we have between Kenya, Uganda, and Tanzania; Mozambique, Malawi, and Zambia; Egypt and Tunisia; Thailand, Cambodia, Laos, and Vietnam; and Argentina and Uruguay. These stakeholders from various sectors of the economy are being brought together to assess climate change vulnerabilities and cost-effective adaptation options. It is therefore not surprising that the AIACC was able to select top scientists in the developing countries in 2002 to participate in the IPCC's 4th Assessment Report with great ease through the established network of AIACC scientists. The nomination of these scientists in the developing countries also broadened their horizons and enhanced their level of professionalism among their counterparts across the globe. Both the local and international activities have actually assisted most of the AIACC participants to become key actors in international activities that relate to climate change. As a matter of fact, some of the participants have received international grants from organizations such as the GEF, the MacArthur Foundation, the Inter-American Institute for Global Change Research, the Asia-Pacific Network and others (Leary and Kulkarni 2007).

Model of Climate Change Education: A Case Study from the AIACC Project

This section describes the capacity-building activities of the AIACC project at the Obafemi Awolowo University, Ile–Ife, Nigeria. It has been suggested that this model be used in other universities to build and strengthen internal capacity in similar disciplines. This comes from the fact that the project combined the three cardinal components of capacity building in the execution of the projects.

The title of the project is "Climate Change, Climate Variability and Food Security in sub-Saharan West Africa". This final title was arrived at after several interactions with the AIACC Science Director and his team. Obafemi Awolowo

University, Ile Ife, Nigeria is the administering institution. Other institutions that participated in the project were the University of Lagos, Lagos and University of Maiduguri, Maiduguri, Nigeria. Although the main area of focus is sensitivity analysis and impact assessment, the analysis in the project also extends to the assessment of human development of peasant farmers.

The country of primary focus is Nigeria. The country was adopted as a sample area for sub-Saharan West Africa because of the fact that the country truly represents the climatic profile from the humid to the semi-arid ends of the project region. All the indicator vegetation types of the various climate types are present in the country. Thus, northwards from the very humid, eastern, coastal locations, to the boundary with the desert, the vegetation profile includes moist evergreen rainforests, dry semi-evergreen rainforests, derived savannah, southern guinea savannah, northern guinea savannah, sudan savannah, and sahel savannah (Adejuwon 2006).

One of the most important aspects of the project is capacity building. It was observed that the research culture at the university was at a low point when the project was approved for funding. The scientists at the university needed impetus. Coupled with the fact that the country was yet to submit its first communication to the UNFCCC ten years after the Rio Earth Summit, it is an indication of the status of research activities at the time. After examining the present situation at the university, it was observed that resident capacity for research on climate change has increased considerably compared with what was obtained three years ago when the project was approved for funding (Adejuwon 2006). An indicator of this analysis is the increase in the number of participating researchers from 7 to 17. The project was approved with only six core research staff apart from the Principal Investigator at inception.

In the same vein, the AIACC-organized workshops; the in-house project seminars; the two-day stakeholders' workshop held from 20–21 September 2004; the stock of equipment including four desktop computers, one laptop computer; and one PowerPoint projector; participation by students, especially at the undergraduate level; the visit of Professor C.G. Knight of Pennsylvania State University; and the study visits of one of the students to the University of Cape Town, South Africa, demonstrated the use of the three cardinal concepts of capacity building suggested in this study. One of the students who worked as a research assistant also presented a paper at the stakeholders' workshop. From the above, three examples of success stories in capacity building could be cited. First, the generally high level of performance by the undergraduate students who opted for climate change as a specialist subject. One of them was awarded the third first-class honours degree in the 43-year history of the Department of Geography at Obafemi Awolowo University (Adejuwon 2006). Second, a member of the research team was awarded a START Fellowship based on a proposal which was derived from the AF23 Project and his experience when he attended the AIACC Workshop in Trieste, Italy, in 2002. Third, another member of the research team who was the most junior member, is the sole author of three of the publications submitted with this report and a joint author of a fourth (Adejuwon 2006).

Conclusion

The focus of this paper has been to examine how climate change projects within the university system can be used to develop and build capacities in the field of climate science. A case study for the AIACC project in sub-Saharan West Africa situated at Obafemi Awolowo University is used to illustrate the model that can be used to achieve this goal.

It was found that the project incorporated all the three cardinal components of capacity building suggested in the study. Assessment of the present situation in the university community of Obafemi Awolowo University, Nigeria, in general, and in the Department of Geography in particular, indicates that resident capacity for research on climate change has increased considerably compared with what was obtained a few years before the project was approved for funding. We proposed that the strategies used in this project to promote and build capacities in the area of climate change could be duplicated not only for projects that have to do with climate change but also other similar projects. Considering the fact that many developed and developing countries are vulnerable to the impacts of climate change, albeit with different intensities, it is recommended that these countries adopt this triadic model so as to increase capacity as well as reduce their levels of vulnerabilities to climate change impacts.

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Chapter 3
Australian Universities, Government Research and the Application of Climate Change Knowledge in Australian Coastal Zone Management

Laura Stocker, Bob Pokrant, David Wood, Nick Harvey, Marcus Haward, Kevin O'Toole, and Tim Smith

Abstract One of the key issues in Australia for sustainable management of the coastal zone is that the science of climate change has not been widely used by decision-makers to inform coastal governance. There exist opportunities to enhance the dialogue between knowledge-makers and decision-makers, and universities have a key role to play in researching and fostering better linkages. At the heart of these linkages lies the principle of more informed engagement between historically disparate groups. In Australia, the new 'Flagship' research programme, funded by the Commonwealth Scientific and Industrial Research Organization (CSIRO), emphasizes their partnering with universities in a more systematic and collaborative manner than previously achieved in such research projects. In order to address sustainability in general and coastal adaptation to climate change in particular, interdisciplinary learning needs to occur between the social and natural sciences; also, transdisciplinary understanding of that interaction needs to be fully developed. New methods of communicative engagement such as computer visualizations and animations, together with deliberative techniques, can help policy-makers and planners reach a better understanding of the significance of the science of climate change impacts on the coast. Deeper engagement across historically disparate groups can lead to the development of epistemological and methodological synergies between social and natural scientists, adaptive learning, reflexive governance, and greater analytical and deliberative understanding among scientists, policymakers and the wider public. This understanding can lead in turn to enhance coastal governance for climate adaptation on the coast.

Keywords Australia · Research · Coastal zones · Management

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Introduction

This chapter reports on a recent Australian research initiative to improve the national and local policy application of climate change and sustainability science, through three types of research engagement. First, we analyse the opportunities presented to both universities and to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) by their ‘Flagship’ program, featuring a partnership approach to research. Second, we focus on the existing and potential interactions and linkages between social and natural science and explore the benefits of interdisciplinary encounters between the two epistemic communities. Third, we critically examine the engagement of the research community with policymakers and other stakeholders. We present the conceptual framework for an innovative CSIRO flagship project which partners the CSIRO with seven universities across Australia. On its completion, the project will produce a fully developed model for improved engagement of climate change research with current Australian coastal planning and policy initiatives and affected communities. The key organising concepts of the CSIRO project are trans- and inter-disciplinarity, reflexive governance, post-normal science, social networks and adaptive learning.

Flagship Programme

Australia’s national science agency is the Commonwealth Scientific and Industrial Research Organisation (CSIRO). In 2003 the National Research Flagships programme was launched as part of the Commonwealth Government’s allocation to CSIRO. The Collaboration Fund provides A$97 million over seven years to the National Research Flagships.[1]

Flagships are designed to respond to national priorities such as energy transformation, water supplies, food, health, minerals, metals, and manufacturing. Relevant to the project discussed here are the Wealth from Oceans Flagship and the Climate Change Adaptation Flagship. Flagships are large-scale, multi-disciplinary, and collaborative in nature, linking CSIRO to industry, NGOs, government, and universities. The total investment of partners to 2010–2011 will be approximately A$1.5 billion, a very substantial research enterprise for Australia. The Flagship programme has brought benefits to universities in terms of opportunities for funding and research partnerships. It could be argued that the programme has meant a ‘leakage’ of funds out of CSIRO to its research partners; however, research partners are required to provide in-kind funding at a ratio of approximately 70 (partner):30 (CSIRO collaboration fund), so in this way intellectual resources also flow back to CSIRO. The Flagships meet their research goals by funding ‘clusters’ which are large-scale research activities, with an emphasis on people and partnerships, and

[1] http://www.csiro.au/partnerships/Flagship-Partnering.html

which are collaborations between CSIRO, industry, universities and other publicly funded research agencies.[2]

There are now 11 clusters established from the first three rounds of funding proposals and nine more are being established from the 2008 funding round. The three clusters relevant to climate change adaptation were all funded in the 2008 round. The clusters relevant to climate change include two from the Climate Change Adaptation Flagship: Human health and climate change adaptation (led by Professor Anthony Capon, ANU), and Regional adaptation to climate change – a case study in SE Queensland (led by Professor Jan McDonald, Griffith University). A third Cluster working on climate change adaptation is in the Wealth from Oceans Flagship. Its long title is “Clearing the path for science uptake: identifying and overcoming the social and institutional barriers to effective and integrated management of Australia’s coastal zone in the face of future change”. This is the Cluster whose work is described in the current chapter. “Future change” clearly includes climate change although there is growing evidence that climate change is already having an impact on socioecological systems. The Cluster is led by Professor David Wood, Curtin University of Technology, and includes seven universities across Australia.

The majority of CSIRO clusters are focused on the natural and physical sciences although there is increasing recognition in the broader scientific community that transdisciplinary and interdisciplinary knowledge, specifically including social sciences and humanities’ disciplines, is fundamental to finding pathways through complex, real-world issues like climate change and coastal adaptation. As was argued in the recent Copenhagen Climate Change Synthesis Report,

> The research required to inform and support a major societal transformation lies primarily in the domains of the humanities and social sciences, which have been much less prominent in the climate change discourse than natural sciences and economics. Nevertheless, their insights into human cultures, behaviours and organisation are crucial to meeting the climate change challenge (Richardson et al. 2009).

The Cluster described in this chapter is social-science based and includes a range of disciplines. The question remains: How can this cross-discipline research be achieved in relation to coastal adaptation to climate change?

Benefits of Interdisciplinarity and Transdisciplinarity

This section explores the existing and potential interactions and linkages between social and natural science and explores the benefits of interdisciplinary encounters between the two epistemic communities. Central to improving the human understanding of the problems posed by climate change is the need for greater cooperation across disciplinary boundaries, particularly between the human and natural

[2] http://www.csiro.au/org/Flagship-Cluster-Applications.html

sciences. Such cooperation is necessary for several reasons. The problem of climate change and its impact on coastal development is a human-induced problem with an environmental dimension. The development of policies to bring about a more sustainable relationship between human activity, climate and coastal development requires a re-thinking of humans' relationship to the natural world. To bring about a change in that relationship, it is important to shift away from the traditional ontological dichotomy which sees human 'nature' as a different order of being from non-human nature. It is this dichotomous thinking, and its institutionalization into a hierarchy of sciences dominated by certain disciplines, that underpinned much policy-making in the 20th century.

During the 19th and early 20th centuries, intellectuals and academics divided the world into three spheres of life organized around the concepts of society, economy, and nature. These three spheres became scientifically and professionally differentiated as separate ontological spaces or basic categories of being, leading to the growth of specific disciplines with their own specific subject matters, epistemologies and epistemic communities. As a result, the technical expert, particularly in natural sciences and, latterly, economics, was elevated to a position of considerable intellectual and decision-making power in public policy. Such a view led people to believe it the task of specific sciences in alliance with government to define the problem to be solved, develop the instruments necessary to bring about a solution to the problem, and to evaluate the success or otherwise of the approach taken. The general public was accorded the role of grateful beneficiary of expert advice and expected to accept whatever policy and planning decisions were made on its behalf. In its more radical forms, this 'rule of the expert' was based on the idea that the only true knowledge was scientific knowledge. All else was superstition, pre-scientific, and non-rational.

In recent years, there have been moves away, at least in Western liberal democracies and some other parts of the world, from a largely authoritarian model of science with its 'top-down' approach to policy-making and planning to one in which science is considered as one component or node in a network of relations, which include policymakers, managers, NGOs, members of the public, and others. In the world of science itself, a key development has been the blurring of the traditional disciplinary boundaries and the search for new ways for scientists of different intellectual and disciplinary backgrounds to work together on academic and policy-related issues and questions. Within the social sciences, this development can be seen in the emergence of new hybrid conceptual frameworks such as ecological economics, environmental anthropology, economic sociology, and political ecology. The natural sciences have seen the growth of sustainability science with its focus on the interaction between human and natural systems[3]. A related development is that of the Earth System Governance Project defined as:

[3]See the new journal 'Sustainability Science' published under the auspices of the Proceedings of the National Academy of Sciences of the United States of America. http://www.pnas.org/site/misc/sustainability.shtml

> ... the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating, and adapting to global and local environmental change and, in particular, earth system transformation, within the normative context of sustainable development (Biermann et al., 2009, p 4).

These initiatives, including the one described here, seek to bring together a diverse range of researchers and policymakers to develop a field of inquiry '... defined by the problems it addresses rather than by the disciplines it employs' (Clarke 2007, p 1,737).

Cooperation across disciplinary boundaries can take many forms ranging from multidisciplinary to transdisciplinary approaches (Eigenbrode et al 2007). Whatever form taken, the underlying reason for such cooperation is to draw on the creativity of intellectual diverse approaches in understanding and offering solutions to the problems posed by climate change, environmental degradation and the creation of sustainable livelihoods.

Engagement of Science with Policy: Adaptive Learning in Australia's Coastal Zone

Australia's coastal zone includes a complex interaction of biophysical and socio-cultural dimensions. Humans have inhabited the coast for tens of thousands of years and have affected, and been affected by, its ecology. Many coastal indigenous peoples dwelt as clans whose livelihoods had several common features. They used marine resources for subsistence, ritual activities and exchange; they viewed saltwater or sea country as inseparable from the land; this connection found expression in stories describing features of sea country, names and sacred sites; and clan identities were closely related to the sea. Clans managed their estates through cultural ceremonies such as song and dance, and traditionally restricted access to the sea according to season, status of clan member, totem and presence of sacred sites (Smyth 1997).

Since European colonization, human uses of and impacts on the coastal zone have increased. Pressures arise from rapid coastal population growth and development; catchment land and water use; marine industries (shipping, tourism, aquaculture, oil and gas extraction, tourism, and fishing); pollution; exotic species; coastal infrastructure development; and climate change and extreme weather events[4]. The coastal zone is now characterised by multiple jurisdictions, differing views on what constitutes appropriate coastal zone management; lack of integrated management

[4] http://www.csiro.au/science/ManagingCoastalWaters.html

tools and continuing controversy on major developments (Kellert 2003; Stocker and Kennedy 2009).

It is the aim of our new Cluster to contribute to an academic and policy integration of the understandings and activities of the wide range of coastal users and to develop conceptual and adaptive approaches that will link improved science to the models of governance, which will contribute to a more resilient and sustainable coastal zone. Below, we describe the conceptual framework for the Cluster. The key research questions are:

- What are the key social and institutional obstacles to adaptive management in the coastal zone?
- How do these obstacles inhibit the incorporation of science into the governance process?
- How can obstacles to better environmental and social governance be reduced?
- What approaches can be taken to enhance science uptake in coastal zone management in the face of these particular challenges?
- To what extent have such improvements occurred in existing Flagship projects?

The key Cluster outcomes will be:

- Enhanced pathways for ongoing science implementation in the coastal zone
- The use of coastal science to enhance uptake of adaptation options to generate economic, social, and environmental wellbeing for Australia.
- Systemic improvements to the management of the coastal zone in Australia.

The Cluster is composed of five themes studied across seven universities (Curtin, Adelaide, Deakin, Flinders, Sunshine Coast, Tasmania, and Wollongong). This is the largest number of universities in any such collaboration in Australia. The themes are: governance, sociocultural context, knowledge systems, and adaptive learning. The various themes are brought together by a keystone theme, whose role is integration, analysis, and synthesis. The universities will interact on a regular basis with the relevant CSIRO scientists and their research programmes to ensure a two-way exchange of ideas and findings.

Cluster Themes

A schematic diagram, showing the key cluster themes, their relationships and key research questions, is given below (Fig. 1). It depicts the biophysical context as an external envelope; changes in this context are a driver for this project but we do not research them directly. Within this is the sociocultural context, which in turn contains the spheres of governance and knowledge systems in dialogue via the process of adaptive learning. In fact, all aspects of the system are mutually constitutive. Core concepts are detailed below.

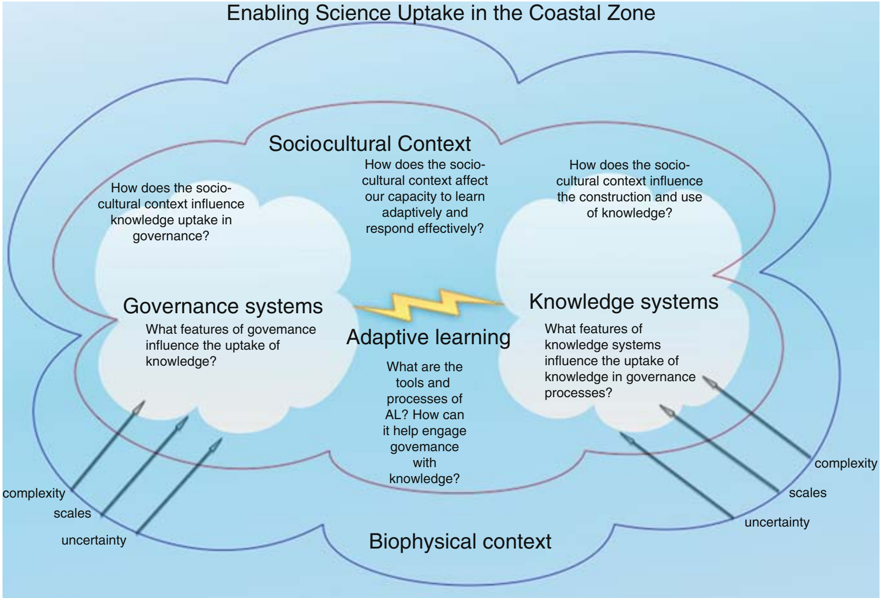

Fig. 1 Enabling science uptake in Australia's coastal zone: the cluster themes and their broad research questions

Biophysical Context

The coastal zone of mainland Australia is over 36,000 km long and includes tropical and temperate climates, ancient and recent geological formations, and a variety of onshore and offshore currents. These physical factors interact to support high levels of biological diversity among and within the terrestrial, estuarine, and marine systems that characterise our coastal zone, including dunal systems, coastal heathlands and forests, sandy shores, rocky shores, coastal wetlands, mangroves, coral reefs, temperate reefs, sea-grass meadows, sponge gardens, and island systems. Many of these habitats include endangered and vulnerable species.

Sociocultural Context

The sociocultural context of the coastal zone is comprised of networks and communities of actors who operate within and among formal structures and informal systems, and whose world views and values differ widely. The sociocultural context is the formative milieu in which human activity is generated and mediated. It interacts continually with the biophysical context within which human activity is embedded, creating a socioecological system. In relation to coastal adaptation, this interaction is characterised by multiple scales, complexity, and uncertainty.

The sociocultural context of the coastal zone strongly influences its adaptive management. Specifically, the sociocultural context influences: the politics and practice of knowledge generation, dissemination, and use; the process of governance; and actors' ability to learn and respond adaptively. The sociocultural Context Theme thus provides an envelope in which the other Cluster Themes are located conceptually and are mutually constitutive (see Fig. 1). All cluster themes and the underlying conceptual elements are mutually constitutive.

The sociocultural Context Theme (2) of the Cluster specifically investigates the informal and formal relations among community, industry, universities, and government in relation to knowledge formation, its use in decision-making, and the identification of obstacles to and opportunities for adaptive coastal management.

Non-technical barriers to effective coastal zone management can arise from structural or systemic features of the sociocultural context, including formal institutional and governance arrangements (see Theme 1). Non-technical barriers to coastal adaptation can also arise from informal aspects of social function including those driven by culture, psychology, politics, and those arising from social processes such as short-term decision-making and vested interests. In Theme 2, these aspects are researched in terms of the influence on decision-making in the coastal zone of divergent sociocultural perspectives; the understandings, concerns and behaviours of actors; and the social and other relationships among actors.

The degree and substance of this influence is assessed in Theme 2 by analysing the bases of significant past decisions, using detailed interviews and documents. These results can in turn inform governance processes (Theme 1), knowledge generation and communication (Theme 3), and learning approaches (Theme 4).

Governance

Governance is an aspect of sociocultural context and refers to the patterns that derive from actual managerial and governing practices; the complex interactions among state and non-state actors; and the stretching of governance systems across temporal and spatial scales (Adger and Jordan 2009). In order for knowledge to be incorporated into governance systems, knowledge needs to be accessible and the governance process receptive to such knowledge. This two-way dialogue can be greatly enhanced, especially in the complex and uncertain domain of coastal management, by adaptive learning. The Governance Theme (1) of this Cluster addresses what kinds of governance arrangements are most likely to enable uptake of knowledge about coastal adaptation and generate on-ground solutions.

Governance of the coastal zone in Australia includes the institutional authorities, processes, and procedures used for guiding strategic and key operational decisions about the coastal zone. It comprises not only complexly interacting levels of formal government (federal, state, and local) but also development commissions, NGOs, Indigenous Native Title holders, and other stakeholders. The influence of a changing sociocultural context in Western democracies since the 1970s has meant a gradual shift from strong central government as the key decision-maker to a system of governance that includes the fragmentation and sharing of responsibility and power; the decentralization and 'agentization' of policy formulation and implementation; an increasing reliance on partnerships and networks; and new deliberative ways of consultation and dialogue about policy (Peters and Pierre 1998; de Loë et al 2009). These changes create complexities in the way knowledge can be understood, communicated and implemented. In the coastal zone, making the transition from government to governance typically demands a change in thinking about who is responsible for what, how decisions should be made, what kinds of knowledge should be used for the decisions, who is accountable, and how social and ecological systems are interconnected (de Loë et al 2009). The contemporary emphasis on reflexive governance takes this trend even further and emphasises that governance is itself part of the dynamic system that is governed, and is therefore oriented towards continued learning and modulating ongoing developments, rather than towards perfect knowledge and maximising control (Kemp et al 2005). Through these processes, structural and institutional obstacles to knowledge uptake can be identified, and pathways to a better knowledge-governance partnership developed.

Theme 1 researches the kinds of governance arrangements that are most likely to enable uptake of knowledge about coastal adaptation and generate adaptive solutions, by drawing on practices of transition management such as visualisation exercises, transdisciplinary research, deliberative workshops and trials in governance (Kemp et al 2005), including the City of Bunbury.

Knowledge Systems

CSIRO have generated a substantial body of scientific data and models about likely impacts (e.g., for coastal climate change impacts, see Church et al 2006) from which decision-makers and stakeholders should be able to act to improve governance of the coast. Specific initiatives include, inter alia:

- The Derwent-Huon region in Tasmania and the INFORMD project based on this region
- South-East Queensland Healthy Waterways Partnership
- Ningaloo Collaboration Cluster
- North-West Shelf Project

Lay and traditional knowledge systems also report evidence of, for example, climate change. However, while some progress has been made in managing these changes, decision-makers and stakeholders have generally been slow to develop and implement policies and management strategies. Slowness in adapting to climate change on the coast is by no means limited to Australia (Tribbia and Moser 2008). At its core lies the persistent phenomenon referred to as the science-policy divide (May 2002; Reid 2004; Saner 2007), which has particular characteristics in the coastal zone.

The Knowledge Systems Theme (3) of this Cluster analyses this process of knowledge diffusion as it presently affects coastal zone management. It addresses both obstacles to uptake, and how the different forms of knowledge – scientific, managerial, lay, and indigenous – can better influence the decision-making process and outcomes for end users of that knowledge.

The current impact of science on the policy process can be analysed according to Figure 2, hereafter referred to as the 'De la Mare model', shows a flow from science to political decision. As decisions move into the policy development/political decision phase, the level of active science input declines. De La Mare's model demonstrates the existence of feedback loops and indirect links although they are weak or absent. These loops and links are often absent from the standard account of uptake (e.g. May 2002).

A more sophisticated representation of an improved pathway is represented in Fig. 3, which shows much stronger feedback from the policy and political domain in terms of defining information needs and policy impact. In addition there are stronger forward links such as the effect of scientific research on properties of policy options. Rather than being a simple linear process, a complex set of engagements and relationships can develop over time (Vogel et al 2007).

Thus, a current model of the interface between science, policy, and practice suggests a complex terrain that is a multi-level system of governance and knowledge production among a range of actors engaged in understanding and managing environment–society interactions (Vogel et al 2007). This model is relevant to the dynamic, complex socioecological system that makes up the coastal zone.

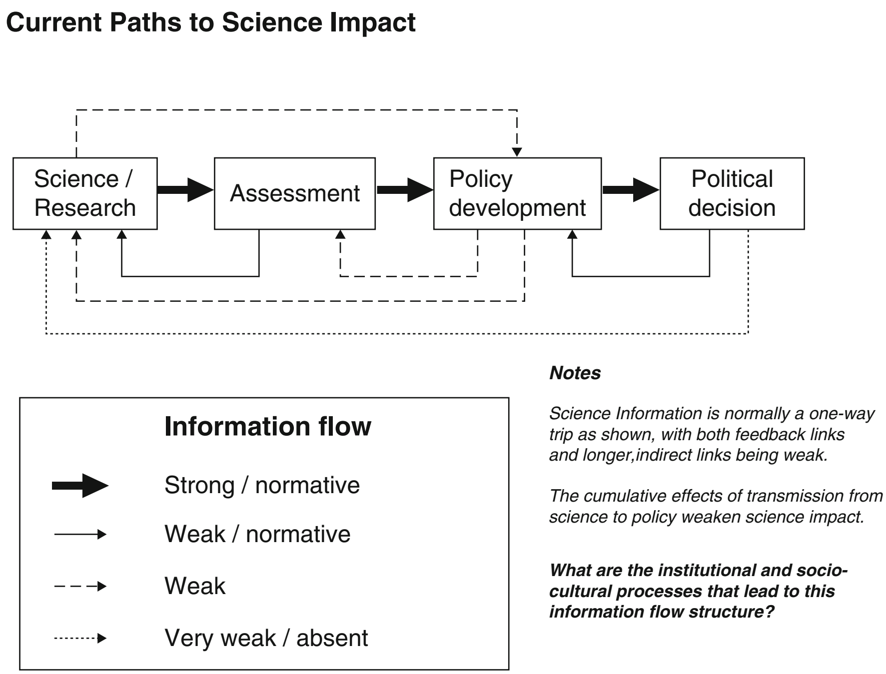

Fig. 2 Current paths to uptake
Source: Bill De La Mare, pers. comm.

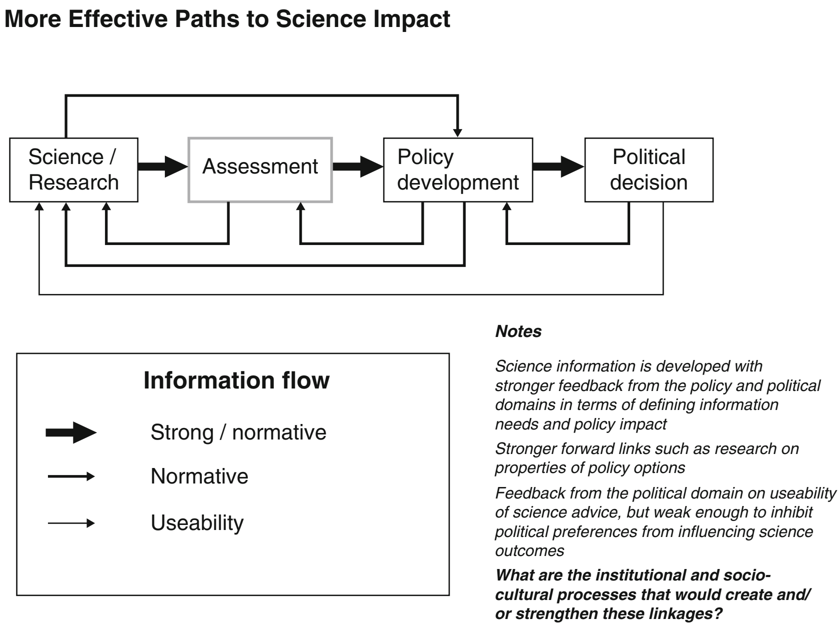

Fig. 3 More effective paths to uptake
Source: Bill De La Mare, pers. comm.

The political domain is potentially able to improve the usability and relevance of science through feedback loops (what policy-makers and planners want to know and in what form), but without actually dictating science outcomes.

Currently there are perceived obstacles to science uptake in the model represented in Fig. 3, or at least differences in perspective between scientists, planners, and politicians about the role and value of science relative to other influential factors. There is a particular challenge posed by the analysis/advocacy dichotomy where valuable science inputs can be diminished through interventions in the decision-making process. Policymakers, planners, and politicians may have different attitudes from scientists in relation to the relative importance of:

- Scale, uncertainty and complexity
- Economism, power, interest groups, and legal issues in the policy space (May 2002)
- Constituencies, party platforms, federal/state/local relations, caucus, cabinet, parliament, public opinion, and media focus in the political space (May 2002)

A lack of communicative engagement between knowledge and governance systems about these issues threatens the legitimacy, accountability, and efficacy of the systems. It also produces gaps between knowledge, governance, and on-ground change. That is, there is an implementation gap (Scherr and Barnhizer 1997) between the knowledge of the need for changing practices to achieve sustainable coastal management on one hand, and actual effective on-coast adaptation on the other. Such an implementation gap will lead to lack of resilience and to unsustainability in coastal communities (Beatley 2009). An implementation gap suggests there are opportunities to improve knowledge and governance (Howlett 2001) systems, and their interaction, in order to achieve resilience and sustainability in the coastal zone (Adger et al 2005).

Novotny et al (2001) propose what they refer to as 'socially robust knowledge', which involves the contextualization of knowledge as the key to producing science for public policy and practice purposes. They propose adopting forms of knowledge that gain strength from their embeddedness in society. The problem is how to isinstitutionalize polycentric, interactive, and multipartite processes of knowledge-making within institutions that have worked for decades at keeping expert knowledge away from the policy and politics (Vogel et al 2007).

Contemporary experience and theory suggest the need for greater reflexivity, by which is meant the need to recognise how governance shapes, and is shaped by, knowledge systems and broader societal loops and contexts, as well as by its own workings; and the need to challenge the foundations of systems, find alternatives, and change shapes (Voβ et al 2006).

In order to move to a preferred uptake pathway in which there are stronger and more constructive feedback loops and links, there is a requirement for different institutional and sociocultural processes that enable better dialogue between knowledge in public policy. For example, substantial interest has grown in 'boundary organisations' that can form a communication link and provide information brokering services between knowledge and governance systems (Vogel et al 2007). In addition, new processes are needed to engage the decision-makers and stakeholders in scientific data and models that relate to building resilient communities and sustainably managing the coastal zone.

Features of these new processes are likely to include:

- Units of analysis which are strongly coupled, jointly determined, nonlinear, complex socioecological systems
- Integrated research which is transdisciplinary and interdisciplinary as well as disciplinary
- A focus on integration as well as analysis in seeking 'truth'
- Inclusion of qualitative values, rigorously treated
- Explicit treatment of uncertainty with reflexive, iterative, and adaptive approaches
- Incorporation of non-scientific knowledges
- Inter-paradigmatic dialogues and adaptive learning
- Stakeholder involvement
- Dealing with multiple scales

(*Sources*: Dovers 2005; Modvar and Gallopín 2005; Guimarães Pereira and Funtowicz 2006).

Theme 3 applies many of the above-listed methodological processes to generate a picture of the existing 'complex terrain' of science uptake in coastal zone management and to produce recommendations for enabling pathways to knowledge uptake.

Adaptive Learning

Complexity, uncertainty, and high decision stakes are typical characteristics of many coastal systems (Smith 2010). Adaptive management is an important paradigm for responding to these characteristics within coastal systems, yet little attention has been focused on mechanisms crucial to its success (Smith and Smith 2006). Adaptive learning drives the adaptive management process by facilitating connections between science and management processes – and thereby maximizes pathways to science uptake. Adaptive learning supports reflexive governance and deliberative approaches in handling pervasive uncertainty and conflict resolution among competing interests. It also supports knowledge-makers to learn from and respond to the requirements of governance. The Adaptive Learning Theme (4) analyses how a more communicative relationship between knowledge-makers and decision-makers could be enabled for the coastal zone, and how learning can be better institutionalized within coastal management organizations. It also helps inform the process of integration among the various themes of the Cluster.

Integration, Analysis, and Synthesis

Theme 5, Integration, Analysis, and Synthesis plays an active role in bringing the other themes together, but it generates insights and analyses that are greater than the sum of individual themes. The products of each of the other four Themes, along with selected existing CSIRO knowledge and experience, are collated, synthezised, and analysed on an ongoing basis during the life of the Cluster. Integrating, distilling, and testing common lessons, and understanding why significant divergences may occur, are a key outcome of this Theme. The role is both conceptual and procedural.

Conceptual integration, analysis, and synthesis involve refining and developing the model presented in this research plan, based on Theme results. This process draws on localised research findings from the individual themes to develop collective general theory and models, as distinct from a set of individual case studies. Our conceptual process also produces innovative high-level methodological analyses. One key example is exploring the conceptual relationship between actor-based and systems-based methodologies employed by Cluster researchers. The methodology of adaptation is primarily based on an actor-centred understanding of the world. It focuses on the agency of social actors to respond to specific environmental stimuli, and emphasises the reduction of vulnerabilities (Nelson et al 2007). However, a complex systems methodology takes a more dynamic view, and might see adaptive capacity as a core feature of resilient socioecological systems (Nelson et al 2007).

Thus, one important and innovative research task of Theme 5 is to show how actor-based and systems-based methodologies can converge and synergise in improving science uptake in the coastal zone.

Procedurally, a key factor in the effectiveness of the Cluster is the requirement for close collaboration between the Cluster teams, and between the Cluster participants and key CSIRO leaders and staff. Procedurally, an actor-based approach involving intensive deliberative Cluster workshops and adaptive learning strategies is used to enable research integration. A systems-based approach is also used to develop a big-picture analysis of how the Cluster themes interact.

In summary, the Cluster features an integration of actor-based and systems-based epistemologies in analysing knowledge uptake and governance in the coastal zone. It is oriented towards long-term sustainability goals and visions for the Australian coastal zone; it aims to change the ways in which systems operating within this zone are organised; it acknowledges sociocultural normative concerns for the coast; it is highly participatory; and it is based on continual learning using available evidence about coastal systems, and so is reflexive, iterative, and adaptive. (Rotmans et al 2001; Kemp et al 2005; van de Kerkhof and Wieczorek 2005; Loorbach and Rotmans 2006). Specifically, our Cluster engages the researchers themselves in integrative, deliberative discussions (Bammer et al 2007).

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Chapter 4
The Impact of Universities on the Climate Change Process

Javier Benayas, Inmaculada Alonso, David Alba, and Luis Pertierra

Abstract This paper addresses the contribution of the university to the provision and dissemination of sustainable forms of management in an attempt to adhere to the compromise of the Kyoto Protocol. A set of specific actions was developed and implemented by the university regarding issues such as energy efficiency and sustainable transportation. Thus, projects such as ZERO Emissions, The Caravan for the Climate or The Solar Wave are described in the present article as part of the solution to the problem. We discuss the implementation and findings of these projects as feedback from the knowledge acquired. The paper therefore provides some fresh ideas and successful experiences in which we attempt to overcome the barriers to sustainability on the university's campus in relation to climate change.

Keywords Educational · Emissions · Technical · University

Introduction

Climate change is currently acquiring great political relevance, most likely for social and economic reasons. There is increasing concern regarding how and when the commitments of the Kyoto Protocol are to be fulfilled and how to solve the problems deriving from the greenhouse effect. It is becoming patently clear that the means to reduce CO_2 emissions (the main contributor to the greenhouse effect) involves consuming less fossil fuels and gradually substituting these with alternative energy sources respectful to the environment. To achieve all this, there is an evident and pressing need for technological advances that enable more efficient energy use and the resulting decrease in emissions.

We must therefore attempt to provide new complementary models of consumption by the population that tend towards the use of new technologies, along with

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sources of more sustainable energy production. Here we introduce some of the projects that have been developed at Madrid's Autónoma University.

First, we address the issue of why there is so much interest in the role of the university. We believe that the university should take the initiative to deal with, and provide solutions to, the problems facing present-day society, among these, and most urgently, those relating to the sustainability of the planet and to the survival of humankind. Some years ago, Madrid's Autónoma Univeristy formally took up the challenge in relation to sustainability and committed to improving the environmental quality of its campus and thereby, of global sustainability. In 1997, in its Letter Of Commitment to the Agenda 21, the UAM committed to reducing the present-day levels of CO_2 emissions as one of its goals. At the university, emissions into the atmosphere principally result from heavy traffic. Thus, to achieve our objective, we focused on the "Promotion of public transportation and a decrease in the number of private vehicles accessing the UAM's campus". Another objective of the above-mentioned Letter involves the "Reduction of the University's energy consumption through the progressive installation of elements more efficient and improved lighting", in order to promote, in turn, the creation of experimental alternative energy plants in order to facilitate the UAM's attempt to move towards a certain degree of autonomy in relation to energy. These two objectives are apparently easy to reach, but in reality involve great difficulty.

The UAM's environmental commitment began with some modest steps towards reaching the aforementioned objectives. One of these referred to *transportation*, an initial project involving car sharing had to be suspended because of the difficulty it entailed. Meanwhile, the use of public transportation was promoted, with many events aimed at promoting awareness and providing public transport subsidies as the main option with regard to gaining access to the campus. Another step refers to *energy*. Substitution of light sources and switch breakers has reduced energy use in the buildings. A small photovoltaic installation measuring 25 m^2 in the Micro-analysis Centre of Materials is a typical small-scale example of what the Autónoma has implemented in the Campus in order to be less dependent on external energy sources.

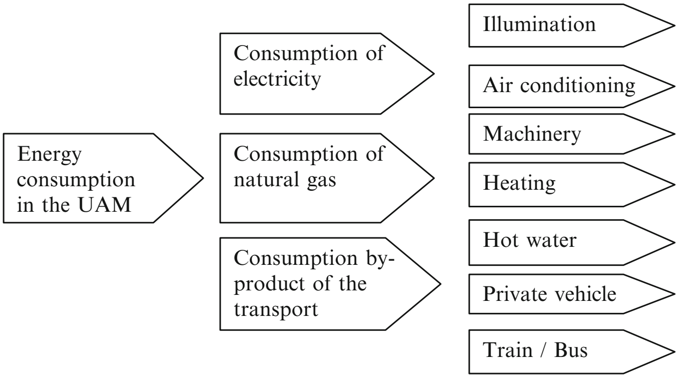
The present paper describes and analyses different initiatives implemented by the UAM over the last few years in an attempt to provide some references for the framework of sustainable universities. In specific terms, we discuss the UAM's zero emissions project, and the technical and educational actions that have arisen from it.

Climate Change in the Context of a University Campus

We regard the Cantoblanco campus of Madrid's Autónoma University (UAM) as a perfect example of tendency towards sustainability through reduction and compensation of its atmospheric emissions. This model can be extrapolated to other places and situations, once the members of the university community, students, teachers, and workers, have modified their habits. Thus, the campus becomes a place in which to discover alternative forms of transport and energy sources. It is more feasible to arrange campaigns and favour the use of these alternatives starting with our study area than in other larger spaces, with their more diverse timetables and activities which would entail much more difficulty.

Diagnosis of Emissions of CO_2 in the UAM

The main aspects in which energy in the UAM is consumed and that as a result the causes of the principal emissions of CO_2 are the following:



The following table shows the total consumption calculated in 2007 for the year and the principal related indicators (Table 1):

The indicator referred to as Forest Area measures the number of hectares of forest required to absorb a determined amount of CO_2 according to the index proposed by the FAO, depending on region, climate conditions, or vegetation type.[1]

Total consumption by the UAM for the year 2007 accounted for 0.32% of the total for the Madrid Regional Autonomy in 2005. This percentage may seem insignificant, but tallies with our country's general educational system in relation to other sectors. For this reason, attention should not only be focused on these data, but rather on the importance of educational centres, in this case the university, of promoting initiatives for a model of sustainable development. Furthermore, the ecological footprint of each member of the Madrid's Autónoma University (UAM) within the campus has been estimated at 0.437 Ha. Thus, the university staff are using an amount of productive land for their daily activity equivalent to 63 times the area occupied by the university (Olaya 2003).

To provide more specific data, the electricity consumed by illumination, air conditioning, computers, and other electrical appliances, totalled 22,517,397 kW h

[1]Index of absorption per hectare 0.7–7.5 Tn de CO_2 yearly. Source www.fao.org

Table 1 Consumptions UAM

Annual data	TEC	Tonnes of CO_2	Tonnes of CO_2 Per capita	Surface of forest (ha)
Electricity	1,937	9,007	0.30	1,201–12,867
Natural gas	2,000	3,546	0.12	473–5,066
Transport	11,795	23,658	0.78	3,154–33,797
Train	2,377	3,324		443–4,749
Bus	933	3,392		453–4,864
Private car	8,485	16,942		2,259–24,203
Total UAM	15,732	36,211	1.10	4828–51,730

Source: Office Ecocampus (2007)

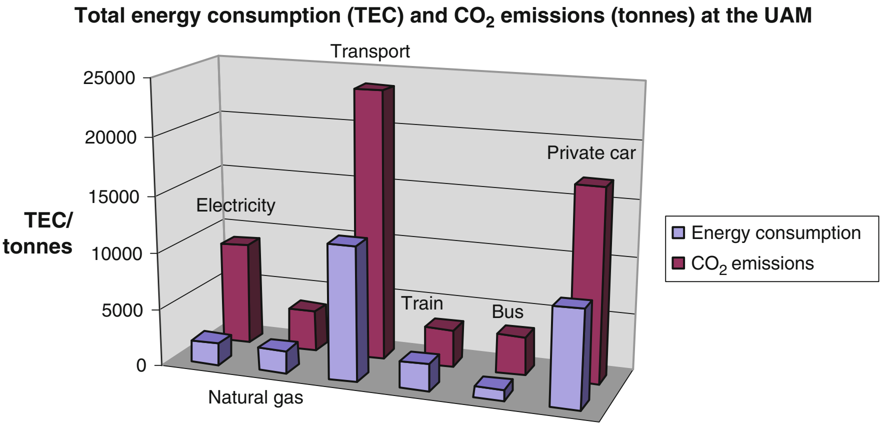


Fig. 1 Total energy consumption (TEC) and CO_2 emissions (tonnes) at the UAM
Source: Office Ecocampus, 2007

in the year 2007. That is, the equivalent of 1,937 tonnes of oil. Furthermore, the natural gas used for heating and hot water was 1,916,733 N m^3, equivalent to 2,000 tons of oil.

The following graphs highlight the importance of transportation in energy consumption and carbon dioxide emissions at the university. This accounts for 70% of total energy consumption, almost three times more than the other types of consumption (Fig. 1).

Approximately 64% of the educational community at this university uses public transport, mainly the train (almost 14,000 people), but use of private transportation currently surpasses use of the bus (almost 12,000 people come by car and nearly 7,000 by bus daily). Perhaps the data do not reflect the number of cars entering the campus (evaluation indicates around 8,500 per day), which is very high, but they do reflect the associated amount of CO_2 emissions, a comparison of which is shown in the previous graphs.

The graph shows that emissions from private vehicles surpasses those from train and bus together, which is why this fact is of greater relevance.

The UAM Zero Emissions Project

This initiative aims to combine efforts in order to minimize the UAM's contribution to climate change through a project including the involvement and awareness of the whole university community. Specifically, it intends to reduce the greenhouse gas emissions by transportation and heating at the UAM. Another step involves improving carbon dioxide absorption by means of repopulation of rustic lots and wastelands at our university. All this will be accompanied by actions aimed at sensitizing the university community and increasing its awareness of good practices for the prevention and minimization of the effects of atmospheric pollution.

General Objective

To minimize the UAM's contribution to climate change through technical improvements and educational tools including the involvement and awareness of all university members: professors, lecturers, students, and administration and service staff.

Specific Objectives

To increase carbon dioxide absorption through repopulation of rustic lots and wastelands at the UAM.

Reducing the emissions derived from the consumption of the heating of the UAM.

Increasing awareness of the fact that the use of renewable energy sources at the university involves both heating and illumination and transportation.

Reducing the origins of greenhouse gas emissions from transportation used by members of the UAM university community.

Sensitizing and raising the awareness of the university community on good practices in order to prevent and minimize the impacts of atmospheric contamination; awareness of climate change.

Technical Initiatives

Repopulation of Rustic Land at the UAM with Natural Forest for Carbon Dioxide Drainage

The objective of this action is to reforest land not zoned for construction. The area surrounding the campus presents housing development and measures approximately 25 ha.

Table 2 Species I

Species	Specimens
Pinus pinea 0.6–0.8 m	18,112
Quercus ilex 0.6–0.8 m	3,825
Fraxinus angustifolia	690
Salix alba	322
Morus fruitless	305
Cupressus sempervirens 0.8–1 m	303
Gleditsia 10–12 cm	195
Prunus dulcis	139
Cedrus deodara 1–1.5 m	48
	23,939

Table 3 Species II

Species	Specimens
Pinus pinea 0.6–0.8 m	390
Fraxinus excelsior	240
Morus fruitless	140
Elaeagnus angustifolia	51
Cupressus sempervirens 0.8–1 m	48
Cedrus deodara 1–1.5 m	48
Arbutus unedo 60–80 cm	47
Ilex aquifolium 60–80 cm	15
Cupressus sempervirens 0.8–1 m	12
Acer pseudoplatanus 10–12 cm	9
Sophora japonica 10–12	9
Robinia pseudoacacia 10–12 cm	8
Populus alba	3
	1,020

Planting involved a great amount of work: Movement of land (60,000 m^3), debris removal (500 m^3), felling of dead trees (100), previous harvesting (78,000 m^2), and conditioning of the corresponding roads in order to plant and maintain trees (412 m). To facilitate the initiative, a road was designed to provide direct access from the train station (RENFE) at Comillas University to the new buildings of the Science Park and the Science Library. The Department of the Environment and the Madrid City Council *Urban Service* assumed the total cost.

The species chosen for planting involve a continuation of the Valdelatas Forest, and are distributed according to Table 2:

Apart from reforestation in non-developable lots, trees were planted in the built-up zone at the same or at a lower density, in order to improve conditions of shade and therefore, environmental quality (Table 3).

In order to complete this intervention, a small area was reforested on the Medicine Faculty Campus at Madrid's La Paz Hospital. A total of 136 trees, comprising nine different species, was planted, the largest being *Fraxinus excelsior* and *Morus fruitless*.

In total, 25,095 feet of trees were planted, more than the total currently existing on both campuses of the university, that is, a total of 1.03 trees for every university user (Table 4).

Table 4 Summary of costs and benefits of the tree plantation (2007)

Budget required (plantating and 2 years' maintenance)	€ 1,278,512.22
Reduction of emissions	500 t CO_2
Date of implementation	2007

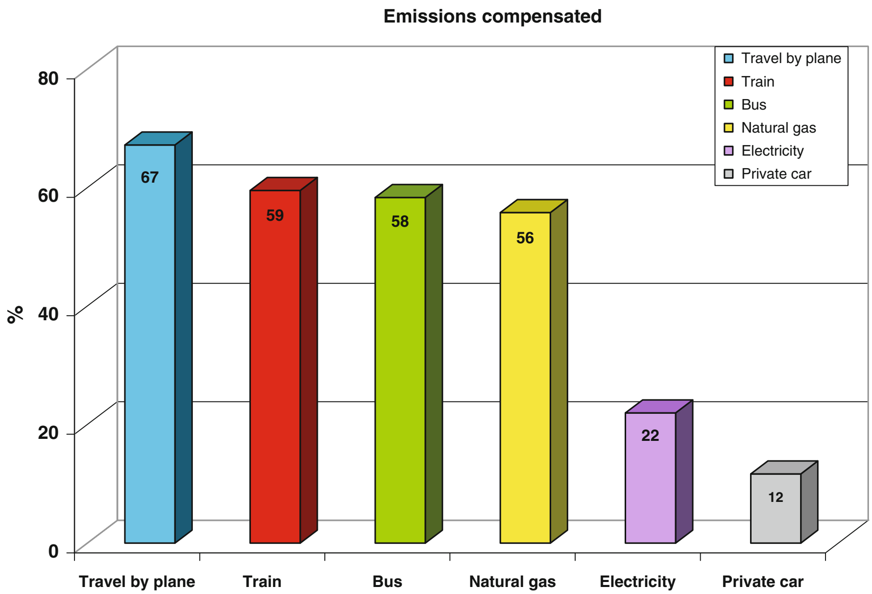


Fig. 2 Emissions compensated by trees planted in the year 2007

The above graphic shows the compensations of CO_2 emissions estimated on the basis of the total forest mass of the campus (Fig. 2).

We assumed the potential of the tree biomass on the campus to fixate by a constant net assimilation of 32.86 kg CO_2/(tree x year). The total amount of CO_2 fixed is equivalent to 5.05% of total emissions, lower than what is recommendable for our university. If the proportion of CO_2 emitted is considered sector by sector, trees are capable of absorbing 67% of the CO_2 emitted by public transport or 12% of the gases emitted by private transport, the sector that causes greatest concern.

Substitution of the UAM Central Boiler with Individual Boilers for Each Building

We estimate that substitution of the present steam power plant for heating water to 120 °C with seven individual steam power plants, heating to 90 °C, in the area of the buildings will provide the following savings:

Table 5 Summary of costs and benefits of substituting of the central boiler (2007)

Budget required	€ 2,200,000
Energy saving	1% of total consumption
Decrease in CO_2 emissions	500 t
Date of implementation	2007

- Primary-circuit circulation pumps for pumping hot water from the old steam power plant to the exchangers in the buildings: a saving of 100% of electric power used to this end.
- We estimate that the performance of the old boilers, due to their condition and age, is no more than 75%. If we consider that the new high-performance boilers installed present a performance of 95%, this represents a saving of 20% of the energy habitually used.
- Losses of hot water at a temperature of 120 °C and pumped from the steam power plant to the exchangers in the buildings. We estimate that, due to the length and condition of the isolations/insulation system, an energy saving of between 5% and 10% will be made.
- Another big performance loss is to be considered, but this is difficult to quantify, as service is only occasionally and exclusively provided to the buildings, the system being shut down the rest of the time. When necessary, the steam power plant is started up and hot water is pumped for some specific needs; this requires a large amount of energy. The estimate of total saving is approximately 1% of consumption.

The total cost of changing the boilers comes to approximately € 2,200,000 (Table 5).

Solar Photovoltaic Installation

Solar Power Generation Station

For quite some time now, the Madrid's Autónoma University has been working on the installation of a photovoltaic solar power generation station at the Cantoblanco campus. Consideration is currently being given to a project specifically involving a project for the installation of almost 5,000 panels with an annual capacity for over one million Kwh (Table 6).

This project provides for the installation of photovoltaic modules in two zones on different parts of the Campus. The first is installed mainly in the roofs of the Arts, Teacher Training and Economics and Business Studies Faculties. The technical design will ensure that the buildings are affected as little as possible, and a support structure without anchorage and with counterweights will be used to avoid possible damage to the roofs. The second is in the car park between the buildings of

Table 6 Summary of costs and benefits resulting from the installation of a solar photovoltaic station (2008)

Budget required	€ 5.5 million
Energy saving	1,275,000 kWh, equivalent to +/− 300 homes, 5% annual consumption of the campus
Decrease in CO_2 emissions	500 tons
Date of implementation	2008

the Rectory and the Psychology Faculty. The installation of canopies in this car park will constitute an improvement.

Installation and management will be conducted by a private company, which will participate in a public tender. Four companies have been approached in relation to the project. Having appraised the documentation presented, the project was awarded to the enterprise Tuin Zonne, belonging to the Grupo Isolux Corsán holding.

The UAM will assist in the project, providing use of the roofs of the buildings involved, and will obtain in return:

- Improvement of the car park by means of construction of canopies.
- Constituting a role model for the university community and other institutions and administrations.
- Economic benefit by means of yearly rental of space for the panels.
- Promotion and support of renewable energy.

UAM Participatory Solar Wave

The solar power generation station will be accompanied by other smaller stations, with a capacity for 55 kW. We hope to obtain the participation of all members of the university community interested in investing in this photovoltaic solar installation through the issuing of bonds. The investment involved constitutes a significant effort in the fight against climate change, an example within the scope of the academic teaching and provides awareness to other people and generations.

With regard to the technical aspects of the project, the UAM yields, disinterestedly in this case, the use of the roof. The project was executed by the company that publicly tendered the best offer, and final management is provided by the Earth Foundation, who possess expertise in this type of initiative (the Carmel's Market, Barcelona).

Participation in this installation of approximately 300 photovoltaic panels is through acquisition of bonds of between € 1,000 and € 5,000, with an estimated annual profit of 7% over 25 years. A total of 129 people from the university community, their relatives, institutions on the campus and others raised the € 400,000 necessary for the project. Of the 129 people who invested, 54 are women and 75 men, and they are distributed according to the sectors illustrated in Table 7.

This initiative is therefore significant in three aspects. An environmental one, as CO_2 emissions into the atmosphere are reduced. An economic one, because the incentives provided by the legislation in force make the investment profitable.

Table 7 Distribution of the participation in the solar wave

University Community	PAS	18
	PDI	62
	Students	8
	Grant holders	3
	Others	8
Institutions on the Campus	CBMSO, ICMM, CNB	6
Institutions not Belonging To The UAM		6
Personal Relatives of UAM Members		18
Total		129

Table 8 Summary of costs and benefits of the project: Solar wave (2008)

Budget required	€ 400,000
Energy saving	2.275%
Decrease in CO_2 emissions	27.5 t
Date of implementation	2008

Table 9 Summary of costs and benefits for the solar heating installation on the swimming pool (2008)

Budget required	€ 191,520
Energy saving	315,000 Kwh at year (46.5% of the aggregate demand)
Decrease in CO_2 emissions	70.2 t yearly
Date of implementation	2008

And an educational one, because it constitutes an example of commitment to renewable energy and to the fight against long-term climate change by the university community and also makes good use of public spaces (Table 8).

Solar Heating Installation at the Swimming Pool

This project consists of the installation of solar collectors for heating the water in the swimming pool, located in the UAM's air-conditioned sports centre.

According to an internal study, energy consumption by the sports centre in heating (natural gas) in the year 2006 required 42 collectors, with a useful absorption area of 377.20 square metres. 320 square metres of panels would be needed, which could be provided by the roofs of the sports centre and/or of the swimming pools. They should be positioned in a south-facing direction, with an inclination of 40° (Table 9).

Substitution of Public Lighting

The public lighting of the UAM's Cantoblanco Campus comprises 946 lamps, most of these sodium or mercury vapour, distributed throughout 20 command centres lacking any kind of system or device for energy saving. The lights are asymmetrical,

Table 10 Summary of costs and benefits of the substitution of lamps (2008)

Budget required	€ 12,818
Energy saving	85.3 MWh (€ 7,873 yearly)
Date of implementation	2008

Table 11 Summary of costs and benefits of regulating lighting (2008)

Budget required	€ 35,170
Energy saving	116.3 MWh (€ 10,739 yearly)
Date of implementation	2008

Table 12 Reductions in emissions achieved

	Unit	Value
Percentage of emissions reduced for the new lighting on the campus	%	31
CO_2 not emitted annually	ton	79.8
SO_2 not emitted annually	kg	188.6
NOx not emitted annually	kg	128.7
Low/medium-intensity radioactive waste not generated annually	cm^3	559.9
High-intensity radioactive waste not generated annually	g	71.6

street lamps, spheres or mushrooms, and they are turned on and off by means of analogical switches, astronomic clocks or photoelectric cells. This illumination accounts for 3% of the total electricity consumption on the campus.

The steam-driven mercury lamps (inefficient) were first replaced by steam-driven lamps of sodium, which will entail a saving of around 40% of the electricity consumption by public lighting (Table 10).

Regulation of Lighting Level

The second action involved the regulation of the level of illumination provided by the public lighting. It proves beneficial to reduce the level of illumination on a public road after a certain time of night (midnight-1 a.m.) and at dawn, in order to reduce energy consumption. Among the different options, the most recommendable one entails installing double-level ballasts, as these are most effective in reducing consumption without affecting the life or the functioning of the lamps (Table 11).

One of the advantages of saving energy is that emissions of pollutants are reduced. The replacement of the outdoor lighting and the installation of double-level ballasts, will prevent almost 80 t of CO_2 per year from being emitted into the atmosphere, along with relevant amounts of other contaminants, such as SO_2 and NOx. These changes represent a saving similar to the emissions caused by the electricity consumption of 650 Spanish homes (Table 12).

Internal System of Transportation by Bicycle

As a means of reducing emissions from the university traffic, other types of transportation facilities and other forms of mobility are planned; i.e., the bicycle.

The Cantoblanco campus can be accessed by two bicycle lanes. The M-607 motorway (Colmenar road) has one bi-directional cycle lane, isolated from the traffic, between the M-40 ring road and the village of Soto del Real, with a length of 32 km. There is a total of 8 km of bicycle lanes between the towns of Soto del Real (7,900 inhabitants) and Colmenar Viejo (40,000 inhabitants). There are 13 km between Colmenar Viejo and Tres Cantos (39,200 inhabitants) and 11 km between Tres Cantos and the M-40m ring road, which join up with the 60 km of the Green Bicycle Ring of Madrid City. The second bicycle lane leading to the campus runs from Cantoblanco to the town of Alcobendas (101,000 inhabitants) and is 4.3 km long.

In 2007, work was undertaken to connect these lanes with the roads network of the campus, to facilitate access by cyclists. In short, a person cycling from the UAM can ride safely along a route measuring almost 100 km.

It is intended to connect those cycle roads with the Cantoblanco campus, and to provide a maintenance centre, a meeting place, etc., for all users of the UAM bicycle lane, and also to provide a connection between this campus and the rest of the cycle lane network. This maintenance centre will be set up at a premises provided by RENFE (the national railway system) at the Cantoblanco train station. These premises will also serve as a centre for rental, storage, and repair of bicycles used for movement within the campus.

The Internal Bicycle System principally involves a set of bicycles that can be picked up from the travellers' main terminus at the RENFE train station and bus stops and from small car parks lots close to the different buildings, and university pupils and staff in general can return them to the starting points. If a person does not want to use the bicycle on the return trip, he will have to rely on someone to take all the bicycles to the main pick-up points in order for them to be available the following morning. Different forms of bicycle rental will exist, depending upon the university community's different needs:

- Daily or hourly rental: This rate would allow a bicycle to be rented only for one day and even for a shorter time period
- Rental over a long period: This rate is for people who wish to avail of a bicycle over long periods of time, such as 4 months or a whole school year. This is a good system, for example, for people staying on campus.

In an initial phase, the number of available bicycles is calculated at around 100 (25 for occasional rental and 75 for long-term rental). The amount of bicycles may be increased depending upon the success of the project. Thus, half of them would be located in front of the RENFE train station and the rest at the bus stop in front of the Rectory. A small amount will also be kept in the car parks outside every faculty, particularly in front of the *Erasmo of Rotterdam* student residence.

Special facilities will be provided for picking up and leaving the bicycles at the main entrances of the campus, and specific bicycle zones will be signposted to enable coexistence between pedestrians and cyclists in the areas of maximum traffic (Sanz and Kisters 2008).

We believe that in the more open areas of the campus, pedestrians, drivers, and cyclists can safely coexist. Moreover, the speed limit on the campus is 30 km/h, and this speed is recommended by cycling regulations for cyclists to safely join the traffic (Sanz and Kisters 2001).

Other Initiatives

Another measure aimed at diminishing CO_2 emissions has been to promote car sharing by means of a database containing information on the destinations and schedules of the people interested in this initiative. The Ecocampus Office is responsible for contacting people with similar destinations and/or schedules. In order to increase the number of participants, incentives and rewards are currently being studied.

In terms of mobility within the campus, an electric vehicle is used by the internal mail service and for the distribution of materials from the central warehouse, as well as a tricycle for the external mail service.

In order to promote the use of public transport, there is a system of annual economic allowances for administration staff and research and teaching staff who can prove they are using it to travel to the university. Specifically, in the year 2007, 258 people benefited from this initiative, receiving a total of € 137,000 (Table 13).

Global Synthesis: Decrease in Emissions

By means of the abovementioned activities, the UAM will emit 1,217.5 t of CO_2 less annually. However, the associated energy saving only accounts for 6.575% of

Table 13 Global synthesis

Action	Energy saving	Reduction of Co_2 emisisons
Reforestation		500 t
Substitution of central boiler	Estimated 1% of total consumption	40 t
Solar power generation station	5% total consumption campus	500 t
Solar heating installation (swimming pool)	46.5% consumption swimming pool, 0.16% consumption campus	70 t
UAM Solar wave	0.275% consumption campus	27.5 t
Substitution of public lighting	31% consumption lighting 0.14% consumption campus	80 t
Total	6.575%	1,217.5 t

the total. These technical actions are therefore complemented with education campaigns aimed at increasing the ecological awareness of university members.

Education Initiatives

Simulation Games

The "Semana Verde" (Green Week) of Madrid's Autónoma University constitutes a traditional event and is staged every spring. It entails two weeks of activities related to the environment and nature protection staged by different organizations, associations, institutions and coordinated from the Ecocampus Office.

The typology of activities is varied, from a photography contest to a workshop on permaculture, eco-villages and sustainable development, theatre performances, practical workshops for retraining, seminars with ratification of credits of free choice, book presentations, etc. The Environmental Volunteer Programme of the Office for Solidarity and Cooperation, belonging to the Ecocampus Office, is undoubtedly one of the main actors, organizing and participating in a large number of activities.

Among these activities, the simulation games are becoming incresingly relevant, thanks to the great amount of participants and the involvement of lecturers and students. The subjects of the simulation games were:

2001: Experience the Kyoto Protocol negotiations
2002: Experience the Río+10 Summit's negotiations
2003: Young people's strategy for participation in environmental themes of the UN
2006: "Who owes who?" Campaign. Tribunal to judge the legitimacy of the external debt

Due to the important role it played, we should highlight the Simulation Game "Experience the Kyoto Protocol negotiations on climate change", which contributed to the campaign led by the international organization "Earth Day" on the celebration of "Earth Day"; the abovementioned organization highlights it as the only Spanish event in its World Gazette and in its webpage www.earthday.net

Over 100 people became involved in this activity, principally environmental volunteers and Environmental Science students, it was organized by the UAM's Environmental Volunteer Programme together with the Ecocampus Office.

The activity began with the creation of delegations from several countries who were to represent the different interests: the United States, Germany, Spain, China, Brazil, Venezuela, Bangladesh, and Samoa. Over a few weeks, these delegations drew up the views of each of the countries, which were presented on "Earth Day" on 22 April, in a plenary session in which the Kyoto Protocol was negotiated and approved. This session was presided over by the Director of the Division Energy &

Ozone Action belonging to the PNUMA, Mr Rajendra Shende, at a round table in which they participated: Heikki Wildstet, Javier Benayas, Ángela Loeches, the Vice-Rector of Students and Environmental Quality and Ms Teresa Rivera, from the Environment Ministry's Office of Climate Change.

The session initially consisted of a presentation by the members of the table, and Mr. Rajendra Shende's introduction of the theme. Subsequently, each of the delegations presented their initial views on how they would be affected by approval of the actions envisaged in the Kyoto Protocol.

Following a pause for negotiation among delegations, they debated the key points of the session, which included emissions control, the effects of climate change, carbon dioxide sinks, etc. To conclude, Ms Teresa Rivera presented the projects being conducted at the Environment Ministry's Climate Change Office in relation to approving the Kyoto Protocol and complying with the obligations arising from it.

It can be said that the activity was a success, and the key to this is that it was not a one-off event, but rather involved many days of preparation by the different delegations. Likewise, its benefits are evident for the participants themselves, as understanding the role played by China, Samoa, or the United States involves in-depth knowledge of the situation in these countries, especially of aspects related to emissions of atmospheric pollutants and to a profound understanding of the Kyoto Protocol and the successive conferences for its approval.

University Caravan for the Climate

The Rector's Conference of Spanish Universities (CRUE) was concerned with sensitizing society on the more important environmental risks facing the planet, and promoted this project through his technical group of Participation and Environmental Volunteer Work coordinated and led by the UAM's Vice-Rectory of Campus and Environmental Quality, with the collaboraiton of the Biodiversity Foundation, and the company ALSA. "The University Caravan for the Climate" attempts to get the members of the community's 13 universities to promote leadership for actions against climate change, as well as behaviour aimed at reducing greenhouse gasses.

Objectives of the Project

The main objective aims to facilitate the contribution by universities to the fight against climate change, and more specifically, to promote the leadership of the members of the participating universities in actions against climate change and to encourage behaviour intended to reduce greenhouse gas emissions.

Activities Developed

The University Caravan for the Climate is a programme for sensitization and environmental education consisting of the use of an itinerant bus that stops at different Spanish universities, in which a group of volunteers from these universities travel, working to promote awareness activities among members of the university communities participating in the fight against climate change.

The visit of the University Caravan for the Climate to each participating university promoted different activities aimed at disseminating research on climate; facilities were visited and projects undertaken in these universities intended to contribute to the reduction of greenhouse gasses. The following activities have now been developed:

Inter-University Voluntary Enlistment Programme for the Climate

This activity constitutes the basis of the whole programme. The idea involves getting two volunteers from each university to travel in a bus conditioned as an environmental education tool, who are to implement activities to sensitize the university community on the problems of climate change. The Caravan will be accompanied by the coordinator of the project and a technical expert in environmental education, who will promote these activities at each university.

The participating volunteers receive basic training on climate change at their university, setting in motion campaigns of sensitization, etc. To this end, they present, organize, and develop, in association with the university environmental services and volunteers, different climate-change sensitization activities to be developed on each campus during the caravan's visit. On the return to their universities, they will be assigned the task of maintaining the voluntary enlistment programme at each university, increasing the number of volunteers and developing activities to promote and inspect compliance with the commitments acquired by the participants.

The journey of the University Caravan for the Climate will last approximately 30 days. The Caravan will spend around one day at each participating university. A couple of volunteers, along with the technical experts will conduct a follow-up of the activity that can subsequently be edited and disseminated among the universities and interested organizations.

Research Dissemination Seminar

On the event of the Caravan tour, a seminar was organized to disseminate the research by each university on climate change. Taking the format of conferences or round tables, they lasted one morning or one afternoon. Diptychs were designed and distributed.

Sensitization Activities Designed and Developed by the Volunteers for the Climate

These activities will involve games, dynamics, theatre, passacaglias, etc. For the Caravan itself, a bus will be used, as it was designed to disseminate information related to climate change (panels, posters, computers, etc.)

The activities implemented promoted the commitment of the university students to the climate, and proposals were presented for minimizing their contribution to climate change. The activities of the Volunteers for the Climate also served to disseminate the other activities organized during the Caravan's stay at each university.

Visits to Installations and to University Projects Related to Reducing Greenhouse Gas Emisisons

The participating universities are currently working to minimize their contribution to climate change by reducing their emissions of greenhouse gases through the installation of renewable energy sources, the promotion of sustainable transportation, an increase in forested areas, etc. There is a need to inform university members of the initiatives, who are not always aware of the options available, for instance the bicycle rental system, which is not used to the full. The activity will be publicized by means of posters and brochures.

One of the most important aspects of these innovations involves the moral values of the project, that is, the volunteer enlistment programme has been greatly improved as a result of the sensitization activities, which make use of unconventional participatory, dynamic formats, etc., in the environmental education programmes.

The continuity of this project will therefore mainly be based upon training programmes for climate volunteers, who, following the Caravan initiative, are capable of maintaining all the initiatives designed for the purpose (seminars, activities of sensitization, etc.). They can always avail of the support provided by the environmental and volunteer services in the fight against climate change. Moreover, the link between this project and the University Climate Network presents the project online, thus promoting new initiatives that will in turn reach other universities due to the larger number of people joining the Network.

How Actions Were Implemented

It is not difficult to differentiate between the types of actions proposed to date; on one hand, intense campaigns involving a need for sensitization and on the other, the ones that do not require this, like the replacement of the central boiler or the solar energy installations. Nonetheless, it is important to inform the university community of the efforts their university is making to work in the most sustainable way possible. The Web of the Ecocampus Office can be used preferentially in this sense and for the delivery of documentary material, such as postcards, brochures, posters, etc.

Now that the university is moving towards efficient energy use involving the sensible use of renewable sources, this is a good time to organize seminars, courses, lectures, etc, in order to involve the community in these initiatives and to cover the training needs related to energy saving; efficiency and renewable sources.

Conclusions

The Autónoma University of Madrid, an academic institution where 33,000 people work or study everyday, is developing an environmental management model in which technical measures complement educational actions in accordance with its commitment to sustainable development and to the fight against climate change. Technical measures have been designed to diminish CO_2 emissions through improved efficiency of the boiler or reduced energy consumption by the campus street lighting. Furthermore, three solar panel systems for electricity production will be installed, one of them involving the participation of the university staff. Other activities focus on encouraging sustainable mobility through economic incentives, and on promoting the use of the bicycle to, from, and within the campus. Pedagogic activities are intended to inform university members of environmental problems in order to increase their involvement in the fight against climate change and in the sensible use of natural resources. The "University Caravan for the Climate", and innovative, original, and participatory project, coordinates activities in another twelve Spanish universities.

Two main aspects were considered in relation to university involvement in climate change problems. First, there was a need to renew the energy systems and to reorganize transport in order to reduce the university's global CO_2 emissions. And second, equally important, to communicate the message to the university community in order to obtain the necessary participation and to extrapolate efforts to the personal level, in itself a pressing need.

The overall goal of the policy and of the projects implemented was to achieve the university's autonomy in relation to energy production. Optimization of the current systems together with new energy-saving technologies have been put in place. Planting trees served both to compensate emissions and as an educational programme. The solar wave provided the opportunity to participate in the construction of a solar plant on the campus, with the resulting ecological and economical benefits. There was also a radical need to redesign the transport system. It was also necessary to promote transport involving a low cost to the environment, which was supported by the bicycle rental system and public transport bonuses.

These projects, however, are meaningless without educational activities to draw attention to the problems we are facing and to the solutions and aid provided in this sense. Several actions were implemented to capture the interest of the Spanish university community. It could be said that the Caravan for the Climate was highly successful and made a great impact. Here, we highlight the need for cooperation among universities in bigger awareness campaigns. Politicians, managers, and the public were all involved. All our efforts have attracted a great amount of attention, thus constituting an opportunity for further cooperation all the stakeholders involved.

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Chapter 5
University of Minnesota Water-Based Nitrogen Budget

Erica K. Schram and Jim A. Perry

Abstract Climate change will impact elemental cycles; understanding such impacts can empower students to act toward sustainability and accountability. Fluxes of nitrogen contributing to campus ground and surface water pollution have not been studied in detail. This paper presents a water-based nitrogen budget for teaching, using the University of Minnesota campus as a model.

We created three annual nitrogen budgets (2003–2005). Data were collected from interviews and published and unpublished papers. All ground or surface water nitrogen fluxes were considered. The campus represents a nitrogen sink; this could be due to nitrogen accumulation in soil, or to uncertainties in our estimation of gaseous losses or biological fixation pathways. More research is needed to assess accuracy and significance of this apparent sink. This paper shows that climate change will affect many elemental cycles; nitrogen perhaps most importantly. A water-based nitrogen budget is a unique approach to water pollution which could be used on university campuses to guide campus-mediated nitrogen pollution and promote sustainability.

Keywords Campus sustainability · Nitrogen budget · Water resources

Introduction

Nitrogen pollution of water resources causes diverse problems that affect ecosystem functioning and human health (Carpenter et al 1998; Janzen et al 2003; Smil, 1999; Wakida and Lerner 2005). Humans have contributed to nitrogen pollution through combustion of fossil fuels, fertilizer production and cultivation of nitrogen-fixing crops (Galloway, 1998; Vitousek et al 1997). Increased anthropogenic nitrogen inputs have led to increased transfer of nitrogen to rivers and other water bodies, along with increased levels of volatilization, denitrification, and export to groundwater (Galloway 1998; Goolsby et al 2000; Janzen et al 2003; Smil 1999). Nitrogen cycles through our atmosphere, hydrosphere, and lithosphere following

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rates and paths that are critical to ecosystems and human well-being (Zheng et al 2002). Climate changes will certainly affect those rates and will have a significant impact on local nitrogen cycles (Dueri et al 2007).

Few urban water quality studies have assessed multi-year nutrient budgets and fluxes in urban watersheds (Groffman et al 2004). Urban ecosystems, including college campuses have fluxes of water and nutrients that impact water quality (Groffman et al 2004; Savanick et al 2007). Identifying nutrient fluxes, including nitrogen on university campuses is one way to help reduce pollution, enhance campus sustainability, and increase understanding of how climate changes might affect nitrogen cycles. A nitrogen budget is an expressive tool that allows quantifying and evaluating nitrogen cycling in ecosystems; nitrogen budgets are effective ways to express dynamics of ecosystems that contain both agricultural and urban areas (Baker et al 2001).

Fluxes displayed in a nitrogen budget can be used to target campus areas that are contributing to excess nitrogen so best management practices can be implemented. Nitrogen budgets can also be used to promote accountability by providing a mechanism to track nitrogen as management practices are implemented.

Tools like nitrogen budgets are valuable because university sustainability is becoming increasingly important. Universities are more aware of their environmental impacts and as a result, many colleges are making efforts to be more sustainable (Savanick 2004). For example, the University of Minnesota has adopted a sustainability policy that states the university will incorporate “sustainability into its teaching, research and outreach and the operations that support them” (UMN Board of Regents Policy, 2004). In addition, the University will strive to stop pollution at its source and be a leader in “promoting and demonstrating sustainability” (UMN Board of Regents Policy 2004).

This paper presents a water-based nitrogen budget for the St. Paul Campus of the University of Minnesota. The budget identifies fluxes of nitrogen entering ground and surface water on campus. The sources and amounts of campus-based nitrogen contributing to pollution of ground and surface water have not previously been studied in detail. The water-based nitrogen budget developed here refines the overall campus nitrogen budget of Savanick et al (2007). Development of this budget is valuable because campus groundwater is vulnerable to contamination from nitrogen, as are surface water resources that receive nitrogen-enriched storm water run-off. This vulnerability will increase as climate changes progress. The resulting budget quantifies our understanding of nitrogen dynamics in these settings and empowers informed decision-making about campus landscape management. It also serves as a platform for teaching on this and other campuses.

Study Area

The St. Paul Campus, part of the University of Minnesota Twin Cities Campus is surrounded by residential land and the Minnesota State Fairgrounds. The developed areas of campus are typical of most campuses (i.e., buildings, roadways, lawns) while the agricultural areas include fields, barns, and a tree nursery. The campus also contains family housing, a heating plant, soccer stadium, farm museum, and golf course.

Storm water run-off, including run-off from a portion of tile-drained agricultural fields connected to the storm water system flows through a forebay and into Sarita Wetland, a small semi-permanent wetland in the south-east corner of campus (Alexander et al 2005; Warnke 2007). This wetland is topographically the lowest point on campus; the wetland and its forebay have strong groundwater recharge (Alexander et al 2005). Underneath the campus is a regional aquitard which creates a shallow, surficial aquifer (Alexander, et al 2005; Kestrel Design Group 2006). This aquifer has a high risk of contamination as waters are trapped between surface sand and gravel sediments and the aquitard (Alexander et al 2005; Kestrel Design Group 2006).

Methods

The area for which we developed the budget was the immediate St. Paul Campus (i.e., excluding the off-site Les Bolstad Golf Course, Gibbs Farm Museum and Robbie Soccer Stadium). The total area was approximately 182 ha. Data from 2003, 2004, and 2005 were used to create three annual nitrogen budgets. Data were collected from interviews with campus personnel as well as published and unpublished papers. All nitrogen input and output paths that included ground or surface water were considered in the budget.

Nitrogen inputs to the system were: commercial fertilizer, animal manure, atmospheric deposition, and biological fixation. Although manure is typically considered an internal transfer in nitrogen budgets, here it is considered an input to simplify the model; only manure applied to agricultural fields was considered. Outputs from the system were: agricultural export, crop senescence, leaching to groundwater, denitrification, volatilization, and surface water run-off (Fig. 1).

Results

Nitrogen Input: Commercial Fertilizer

Commercial fertilizer is applied to agricultural fields and turfgrass. Campus turfgrass receives two fertilizer applications per year (Lauer 2007). Total fertilizer application to turfgrass was 1,585 kg N in 2003, 1,595 kg N in 2004 and 1,583 kg N in 2005.

We were unable to obtain data on fertilizer applications for Commonwealth Terrace Cooperative (CTC), the campus married student housing area. We estimated inputs based on slow-release fertilizer application rates for Minnesota (100 kg N ha^{-1} yr^{-1}) (University of Minnesota Extension Service, 2004). At that rate, 1,228 kg N^{-1} yr^{-1} were applied to CTC turfgrass. Total nitrogen application

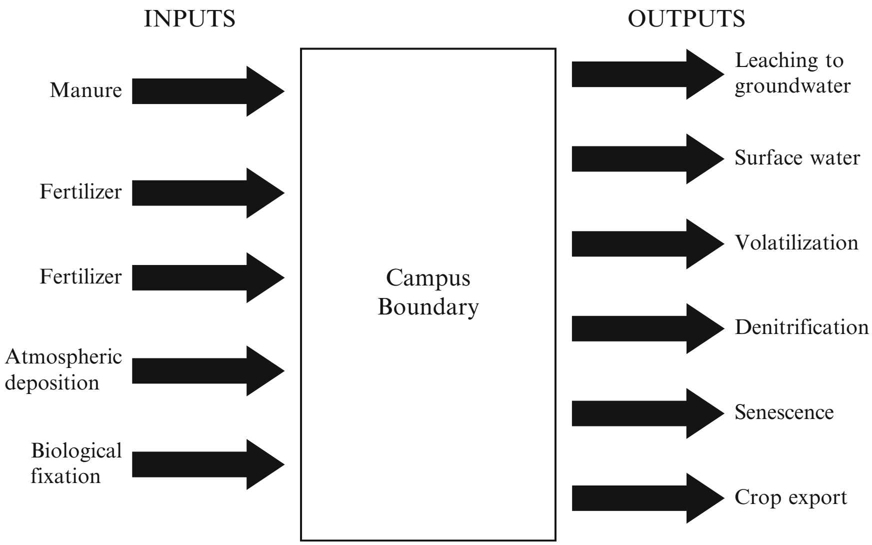

Fig. 1 Nitrogen model for the St. Paul campus system

to all campus turfgrass was 2,813 kg N in 2003, 2,823 kg N in 2003 and 2,811 kg N in 2005. Commercial fertilizer is also added to the agricultural fields on campus. Total applications were 1,545 kg N in 2003, 1,730 kg N in 2004, and 235 kg N in 2005.

Thus, total commercial fertilizer nitrogen input to the study area was 4,358 kg N (23.95 kg N ha^{-1} yr^{-1}) in 2003, 4,553 kg N (25.02 kg N ha^{-1} yr^{-1}) in 2004 and 3,046 kg N (16.74 kg N ha^{-1} yr^{-1}) in 2005.

Nitrogen Input: Animal Manure

Composted dairy manure and liquid manure were also applied to agricultural fields. Total animal manure nitrogen inputs to campus were 3,874 kg N (21.29 kg N ha^{-1} yr^{-1}) in 2003, 4,014 kg N (22.05 kg N ha^{-1} yr^{-1}) in 2004 and 1,900 kg N (10.44 kg N ha^{-1} yr^{-1}) in 2005.

Sum of Fertilizer Inputs

Among all sources, managers applied 5,419 kg N (29.77 kg N ha^{-1} yr^{-1}) in 2003, 5,744 kg N (31.56 kg N ha^{-1} yr^{-1}) in 2004 and 2,135 kg N (11.73 kg N ha^{-1} yr^{-1}) in 2005.

Nitrogen Input: Atmospheric Deposition

Following Savanick et al (2007), the rate of wet deposition on the St. Paul Campus was taken to be that of the closest monitoring station operated by the National Atmospheric Deposition Program (NADP). This site is about 44 km from campus at the Cedar Creek Long Term Ecological Research Site. Deposition rates ranged from 4.04 to 6.72 kg N ha^{-1} yr^{-1} over the three-year study period (National Atmospheric Deposition Program (NRSP-3) 2007). Wet deposition to campus totalled 736 kg N in 2003, 1,070 kg N in 2004 and 1,223 kg N in 2005.

Terrain, vegetation, meteorology, and other factors can influence dry deposition, making it more difficult to measure than wet deposition (Clarke et al 1997; Pratt et al 1996; Smil 1999). In a study of the Mississippi River Basin (MRB), dry deposition of NO_3 was estimated by multiplying wet deposition by 0.70 (i.e., the mean ratio of dry to wet deposition among several sites where wet and dry deposition monitoring stations were co-located) (Goolsby et al 1999). Wet deposition of NO_3 was 1.61 kg N ha kg N ha^{-1} yr^{-1} in 2003, 2.22 kg N ha^{-1} in 2004 and 2.55 kg N ha^{-1} in 2005, among our 182 ha (National Atmospheric Deposition Program (NRSP-3), 2007). Adopting their 0.70 multiplier, dry deposition was 205 kg N in 2003, 284 kg N in 2004 and 325 kg N in 2005.

Total nitrogen input from wet and dry deposition was 941 kg N (5.23 kg N ha^{-1} yr^{-1}) in 2003, 1,354 kg N (7.44 kg N ha^{-1} yr^{-1}) in 2004 and 1,548 kg N (8.51 kg N ha^{-1} yr^{-1}) in 2005.

Nitrogen Input: Biological Fixation

Legume crops contribute nitrogen to the study area. The Minnesota Department of Agriculture (1999) assigns nitrogen credits to guide application rates, recognizing that legumes contribute nitrogen that benefits a later crop. The soybean credit is 45 kg N ha^{-1} and that for alfalfa is 168 kg N ha^{-1} when corn is planted following these crops.

Savanick et al 2007 estimated nitrogen inputs from biological fixation by calculating the amount of nitrogen harvested in nitrogen-fixing crops and adding that to nitrogen left in crop residue on the field. The acreage of individual crops planted on campus is similar each year, so we assumed that nitrogen harvested from nitrogen-fixing crops and nitrogen from crop residue was the same each year (Warnke 2007). There were 1,012 kg N yr^{-1} added to the agricultural fields from crop residue. The amount removed with harvested soybeans and alfalfa was 3,212 kg N yr^{-1} (Table 1). As such, the total input of nitrogen from biological fixation was 4,224 kg N yr^{-1} (23.21 kg N ha^{-1} yr^{-1}).

Table 1 Nitrogen removed in crop harvest

Crop	Hectares[a]	Average yield (kg/ha)[b]	Nitrogen removed with crop (kg)[d]
Soybeans	21.1	149.4	3,151
Corn	10.1	133.5	1,348
Barley	3.7	20.9[c]	77
Oats	5.1	37.3	190
Wheat	6.1	57.7[c]	352
Oil seed rape	0.8	32.5[c]	26
Tree nursery	3.4	N/A	N/A
Turf research	6.1	N/A	N/A
Potatoes	0.4	162.5[c]	65
Alfalfa	0.4	152.5	61
Forage	3.2	N/A	N/A
Vegetables	0.4	8.2[c]	3
Pasture	8.1	N/A	N/A
Total	68.9		5,273

[a]Data from (Warnke, Personal Communication)
[b]Yield data from (National Agricultural Statistics Office, 2007)
[c]Statewide average yield
[d]Nitrogen removal data from (Minnesota Department of Agriculture, 1999)

Nitrogen Output: Agricultural Output

Nitrogen is exported when crops are harvested and removed from the study area. The agricultural fields on campus are experimental; however, we assume that crop yields are similar to those of a typical farm. Average yield information from Washington and Anoka counties was used to estimate crop yields for campus. When data for these counties were not available, statewide yields were used. We have data on nitrogen removed with crop harvest from 2005 and use those as an estimate for 2003 and 2004 (Table 1). As such, 5,273 kg N yr^{-1} (28.97 kg N ha^{-1} yr^{-1}) were removed from the study area through crop export.

Nitrogen Output: Crop Senescence

Crop senescence commonly occurs during the last 10 weeks of the growing season (Burkart et al 2006; Burkart and James 1999). Loss of nitrogen to the atmosphere is mainly in the form of ammonia and can represent a large output from a system (Burkart and James 1999; Smil 1999).

We used Burkart et al (2006), a study of leaching to groundwater under agricultural systems in Iowa, to estimate nitrogen loss rates during senescence. We used a rate of 25 kg N ha^{-1} for maize, soybeans, and wheat, and a rate of 2 kg N ha^{-1} for alfalfa and forage. For other crops, we used 22 kg N ha^{-1}. Pasture grasses were assumed to be consumed before senescence, so no nitrogen loss from pasture was included (following Burkart et al 2006). We also assumed that no nitrogen was lost from potatoes, turf research, or the tree nursery (specific data were not available).

A total of 1,157 kg N yr^{-1} (6.36 kg N ha^{-1} yr^{-1}) were lost to the atmosphere due to crop senescence in 2003–2005.

Nitrogen Output: Leaching

Several variables affect leaching of nitrogen from fertilizer applied to turfgrass and agricultural fields, including soil type, fertilizer type and application rate and timing (Janzen et al 2003; Petrovic 1990). Lerner (2000) used a leaching rate of 10% for nitrogen applied to urban turfgrass. Following that estimate, 281–282 kg N yr^{-1} was leached to groundwater.

Meisinger and Delgado (2002) state that nitrogen loss rates from fertilizer or manure applied to grain-production systems range from 10% to 30%. Savanick et al 2007 used a leaching rate of 20% based on rates from corn-soybean systems in South Central Minnesota.

Approximately 12.5% of the campus agricultural fields are tile-drained (Warnke 2007). We assumed that excess nitrogen in agricultural fields was transported through the storm drain system and not leached to groundwater. Therefore, accepting a 20% leaching rate, 948 kg N leached to groundwater from manure and commercial fertilizer in 2003, 1,005 kg N in 2004 and 374 kg N in 2005.

Janzen et al (2003) estimated that leaching removes 10% of nitrogen from atmospheric deposition in Canadian agroecosystems; we adopted this rate. Only atmospheric deposition falling on pervious surfaces, which make up 68% of our system, was considered available to become leachate. Therefore, 64 kg N in 2003, 92 kg N in 2004 and 105 kg N in 2005 from atmospheric deposition leached to groundwater.

The total leachate to groundwater from manure, commercial fertilizer and atmospheric deposition was 1,293 kg N (7.1 kg N ha^{-1} yr^{-1}) in 2003, 1,379 kg N (7.58 kg N ha^{-1} yr^{-1}) in 2004 and 760 kg N (4.18 kg N ha^{-1} yr^{-1}) in 2005 (Table 2).

Table 2 Nitrogen loss through leaching to groundwater in 2003, 2004, and 2005

	Nitrogen loss (kg N)		
	2003	2004	2005
Manure	678	702	333
Fertilizer (agricultural)	270	303	41
Fertilizer (turf)	281	282	281
Atmospheric deposition	64	92	105
Biological fixation	0	0	0
Total	1,293	1,379	760

Nitrogen Output: Atmospheric Loss – Volatilization

Several authors have reported volatilization losses of 10% of applied fertilizer (Puckett et al 1999; Schlesinger 1992; Smil 1999). At that rate, losses through volatilization were 155 kg N in 2003, 173 kg N in 2004 and 24 kg N in 2005 from commercial fertilizer applied to agricultural crops.

Nitrogen from fertilizer applied to turfgrass can also volatilize to the atmosphere. Studies of volatilization from turfgrass have given a range of results, with the amount of thatch and irrigation strongly influencing results (Horgan et al 2002). We used a 10% volatilization rate based on estimates from commercial agricultural fertilizers. Total volatilization losses from turfgrass fertilizer were 281 kg N in 2003 and 2005, and 282 kg N in 2004.

Volatilization losses of NH_3 from animal manure vary depending on manure type, application method, climate, storage, and handling (Goolsby et al 1999; Puckett et al 1999). In a nitrogen mass-balance budget for west-central Minnesota, volatilization losses of NH_3 from manure were estimated at 35% of total nitrogen (Puckett et al 1999). Using this rate, 1,356 kg N in 2003, 1,405 kg N in 2004, and 665 kg N in 2005 were lost from manure due to volatilization.

Nitrogen can also volatilize into the atmosphere from atmospheric deposition. In a study on the effects of enhanced deposition on nitrogen budgets of semi-natural grasslands, Phoenix et al (2003) found that less than 6% of deposited nitrogen volatilized as ammonia. We used that study to estimate a volatilization rate of 5% from atmospheric deposition from campus. We assumed that only atmospheric deposition from pervious surfaces volatilized; deposition on impervious surfaces was assumed to represent a surface water output. As such, 32 kg N in 2003, 46 kg N in 2004 and 53 kg N in 2005 volatilized to the atmosphere.

Total volatilization output from all sources was 1,824 kg N (10.02 kg N ha^{-1} yr^{-1}) in 2003, 1,906 kg N (10.47 kg N ha^{-1} yr^{-1}) in 2004, and 1,023 kg N (5.62 kg N ha^{-1} yr^{-1}) in 2005 (Table 3).

Table 3 Nitrogen loss through volatilization in 2003, 2004, and 2005

	Nitrogen loss (kg N)		
	2003	2004	2005
Manure	1,356	1,405	665
Fertilizer (agricultural)	155	173	24
Fertilizer (turf)	281	282	281
Atmospheric deposition	32	46	53
Biological fixation	0	0	0
Total	1,824	1,906	1,023

Table 4 Nitrogen loss through denitrification in 2003, 2004, and 2005

	Nitrogen loss (kg N)		
	2003	2004	2005
Manure	387	401	190
Fertilizer (agricultural)	155	173	24
Fertilizer (turf)	281	282	281
Atmospheric deposition	64	92	105
Biological fixation	0	0	0
Total	887	948	600

Nitrogen Output: Atmospheric Loss – Denitrification

There is loss of nitrogen to the atmosphere from denitrification of manure, fertilizer, and atmospheric deposition. According to Smil (1999), denitrification in field- or regional-nitrogen balances is commonly estimated at 10%, which includes animal manure, fertilizer, and atmospheric deposition. We used a denitrification rate of 10% from turf and agricultural fertilizers and estimated an output of 436 kg N in 2003, 455 kg N in 2004, and 305 kg N in 2005. Denitrification at the same rate from manure provided estimates of 387 kg N in 2003, 401 kg N in 2004, and 190 kg N in 2005. Denitrification from atmospheric deposition on pervious surfaces resulted in outputs of 64 kg N in 2003, 92 kg N in 2004, and 105 kg N in 2005. Therefore, the total losses of nitrogen from denitrification were 887 kg N (4.87 kg N ha^{-1} yr^{-1}) in 2003, 948 kg N (5.21 kg N ha^{-1} yr^{-1}) in 2004, and 600 kg N (3.3 kg N ha^{-1} yr^{-1}) in 2005 (Table 4).

Nitrogen Output: Surface Water Outflow

Storm water on the St. Paul Campus drains to Sarita Wetland. Approximately 32% of the campus surfaces are impervious (Paul, 2002). It has been reported that concentrations of nitrogen in run-off from impervious surfaces are twice as large as concentrations in wet deposition, in part due to dry deposition collecting during periods of no precipitation (Valiela et al 1997). Although some storm water on campus runs into areas of turfgrass, we assumed all storm water from impervious surfaces entered the storm drains. Therefore, for this budget 100% of atmospheric deposition landing on impervious surfaces flowed to Sarita Wetland. As a result, 301 kg N in 2003, 433 kg N in 2004, and 495 kg N in 2005 from atmospheric deposition entered Sarita Wetland through the storm drain system.

The portions of agricultural fields that are tile-drained connect to the storm water system which in turn discharges to the Sarita Wetland. Savanick et al (2007) used a rate of 20% to estimate nitrogen export through tile drains based on corn-soybean cropping systems in South Central Minnesota. Following that estimate, 136 kg N

Table 5 Nitrogen loss to surface water in 2003, 2004, and 2005

	Nitrogen loss (kg N)		
	2003	2004	2005
Manure	97	100	48
Fertilizer (agricultural)	39	43	6
Fertilizer (turf)	0	0	0
Atmospheric deposition	301	433	495
Biological fixation	0	0	0
Total	437	576	549

in 2003, 143 kg N in 2004, and 54 kg N in 2005 were exported through surface water outflow.

Surface water run-off from turfgrass does not occur often, with rates commonly being less than 1% of applied fertilizer (Easton and Petrovic 2004; Petrovic 1990). The University of Minnesota's policy on fertilizer application is to avoid spreading any fertilizer on impervious surfaces and any fertilizer that does land on an impervious surface is blown back onto the grass (Lauer 2007). Based on those practices, we assumed there was no surface run-off from fertilizer applied to turfgrass on campus.

The total nitrogen exported through surface water was 437 kg N (2.4 kg N ha^{-1} yr^{-1}) in 2003, 576 kg N (3.17 kg N ha^{-1} yr^{-1}) in 2004, and 549 kg N (3.02 kg N ha^{-1} yr^{-1}) in 2005 (Table 5).

Summary of Inputs and Outputs

In 2003, the total input to campus was 13,397 kg N (73.61 kg N ha^{-1} yr^{-1}), while the total export was 10,871 kg N (59.73 kg N ha^{-1} yr^{-1}). This leaves an accumulation of 2,526 kg N (13.88 kg N ha^{-1} yr^{-1}) in 2003. The total input to campus in 2004 was 14,145 kg N (77.72 kg N ha^{-1} yr^{-1}) and the total export was 11,239 kg N (61.75 kg N ha^{-1} yr^{-1}). During 2004, 2,906 kg N (15.97 kg N ha^{-1} yr^{-1}) accumulated on campus. The total nitrogen input to campus in 2005 was 10,718 kg N (58.89 kg N ha^{-1} yr^{-1}) and the total nitrogen export was 9,362 kg N (51.44 kg N ha^{-1} yr^{-1}). This leaves an accumulation of 1,356 kg N (7.45 kg N ha^{-1} yr^{-1}) in 2005.

Discussion

Impacts on Water Resources

To understand the direct sources of nitrogen entering water resources on the St. Paul Campus, it is necessary to examine nitrogen inputs more closely. Total inputs to surface water were 437 kg N (2.4 kg N ha^{-1} yr^{-1}) in 2003, 576 kg N

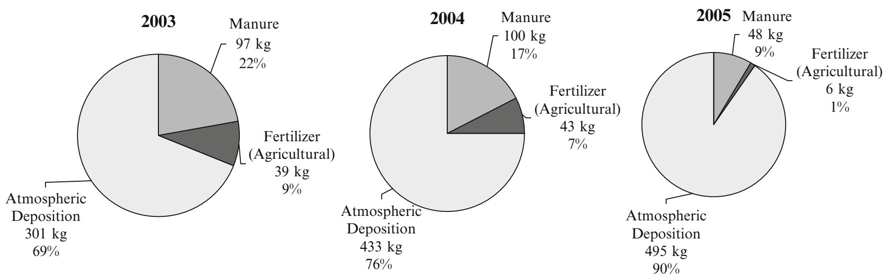

Fig. 2 2003, 2004, and 2005 nitrogen contributions to surface water

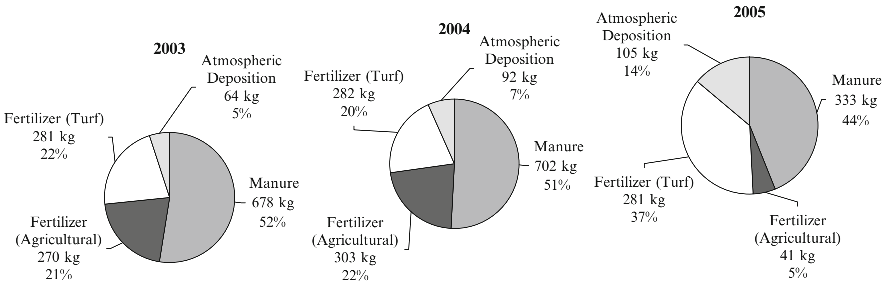

Fig. 3 2003, 2004, and 2005 nitrogen contributions to groundwater

(3.17 kg N ha^{-1} yr^{-1}) in 2004, and 549 kg N (3.02 kg N ha^{-1} yr^{-1}) in 2005 (Fig. 2). Total inputs to groundwater were 1,293 kg N (7.1 kg N ha^{-1} yr^{-1}) in 2003, 1,379 kg N (7.58 kg N ha^{-1} yr^{-1}) in 2004, and 760 kg N (4.18 kg N ha^{-1} yr^{-1}) in 2005 (Fig. 3).

Agricultural fertilizer and manure are deliberately added to the system; atmospheric deposition is not intentionally added but is a large input. Atmospheric deposition was the leading source of nitrogen to surface water in all three years, followed by manure and agricultural fertilizer. Manure, turf, and agricultural fertilizer and atmospheric deposition contributed nitrogen to groundwater. Manure was the source of the most nitrogen to groundwater, followed by commercial fertilizer sources and atmospheric deposition. Total outputs to groundwater account for 7.1–9.8% of the inputs; nitrogen outputs to surface water accounted for 3.3–5.1% of the inputs during the three-year study period. For 2003–2005, 12.2–13.9% of the initial nitrogen inputs on the St. Paul Campus entered ground or surface water.

Monitoring wells on the St. Paul Campus have shown nitrogen levels that exceed the drinking water standard (i.e., >10 mg/l N). Chemical indicators of groundwater recharge suggest that the source of increased nitrogen is ammonia from fertilizers and manure (Alexander et al 2005). Storm water from campus enters Sarita Wetland and then exits through a storm tunnel leading to the Mississippi River. In the absence of other data, we assumed that all nitrogen entering Sarita was exported to the Mississippi. For 2003–2005, the St. Paul Campus contributed 437–549 kg N yr^{-1} to the Mississippi River.

Uncertainties

A total of 12.7–20.5% of the nitrogen inputs are not represented in the outputs of this budget. That represents a sink of 1,356–2,906 kg N yr^{-1} (7.45–15.97 kg N ha^{-1} yr^{-1}). Estimates of gaseous losses from agroecosystems can be subject to large uncertainty (Janzen et al 2003). Ambiguity in denitrification rates due to the variability of soils and environmental conditions can lead to inaccurate estimates of outputs. Additionally, there is a lack of dependable, field-based measurements of nitrogen flux from agricultural areas and from turfgrass and grasslands (Horgan et al 2002; Smil 1999).

The fate of biologically fixed nitrogen is not well-known, although much nitrogen is exported through crop harvest (Baker 2007). We assumed that biologically fixed nitrogen was not lost through leaching, surface water outflow, volatilization, or denitrification. However, nitrate leaching from legumes does occur and volatilization of ammonia can also occur from legume residues left on the field (Crews and Peoples 2004). Nitrogen pathways are complex and biologically fixed nitrogen from legume crops have output flows other than crop export, although they are not well understood. Therefore, losses from biological fixation may have been underestimated in this budget.

The net nitrogen sink could be due to nitrogen accumulation in agricultural soils. Smil (1999) suggests that agricultural soils are accumulating rather than losing nitrogen because of high rates of nitrogen applications to crop lands and sequestration of nitrogen in soil organic matter. Additionally, many nitrogen balance studies throughout the world have shown gains in soil organic nitrogen (Smil, 1999). Farmland around the world may be annually gaining 25–35 kg N ha^{-1} yr^{-1} (Smil 1999). An estimate of 1,275–1,785 kg N yr^{-1} gained by the agricultural soils on the St. Paul Campus would be smaller than Smil's estimate and may be reasonable.

Further Research Needs

Annual monitoring of nitrogen levels in ground and surface water on campus would help refine future campus nitrogen budgets. This, combined with analyses of the major ions in the water and information from the campus nitrogen budget, could give detailed information about the nitrogen flows on campus and lead to more informed management decisions to reduce campus impacts on off-site resources. More research would be required to assess the accuracy and significance of an apparent 12.7–20.5% accumulation of nitrogen on campus, as well as annual variance in nitrogen input and output rates.

Conclusions

Water-based nitrogen budgets allow universities to quantify nitrogen fluxes in order to make informed, sustainable management decisions regarding campus water resources. The 2003, 2004, and 2005 water-based nitrogen budgets for the St. Paul Campus offer a more complete picture of inputs and outputs on campus, specifically nitrogen inputs that include a flow path to ground and surface water. Total inputs to the St. Paul Campus for 2003–2005 ranged from 10,718 to 14,145 kg N yr^{-1} (58.89–77.72 kg N ha^{-1} yr^{-1}). Total outputs from the campus ranged from 9,362 to 11,239 kg N yr^{-1} (51.44–61.75 kg N ha^{-1} yr^{-1}). Between 3.3% and 5.1% of the inputs were exported through Sarita Wetland to the Mississippi River. A total of 7.1–9.8% of the inputs leached to groundwater. This nitrogen budget will aid sustainable management efforts and clarify where improvements could be made to reduce nitrogen pollution from campus.

Nitrogen budgets can also promote accountability through easily identifying how increases or decreases in nitrogen inputs influence outputs. This allows important management areas on campus to be identified, so management plans can be designed and implemented. Nitrogen inputs and outputs could be tracked throughout the years to identify improvements or areas where improvements still needed to occur. This would allow a more thorough understanding of the university's impacts on water resources and lead to action to minimize impacts.

Water resources of the St. Paul Campus are vulnerable to nitrogen pollution. That vulnerability will increase with climate change, especially as increasing storm frequency and severity develop. The nitrogen budget created for this campus has identified nitrogen fluxes that can affect ground and surface water and has laid the foundation for sustainability and accountability measures to reduce nitrogen impacts from campus activities. The budget also offers a tool for teaching about nitrogen cycles and the influence of climate change on elemental cycles.

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Chapter 6
Sustainable Literacy and Climate Change: Engagement, Partnerships, Projects

Julie Matthews and Peter Waterman

Abstract This paper explores the connections between sustainable literacy and climate change. It describes the role of engagement and partnerships and outlines the role which can be played by projects. The pedagogical point made in the paper is that how and why we teach is as significant as what we teach and the knowledge, skills, and ability to understand and act in favour of sustainability can be usefully generated in processes of engagement with the immediate and complex problems that beset local communities.

Keywords Literacy · Partnerships · Projects · Sustainability

Introduction

With real and impending threats posed by global warming and subsequent climate variability and change, professionals are being challenged to develop expertise in environmental decision-making and policy development. This chapter discusses sustainability literacy in relation to climate change adaptation skills in the context of a suite of articulated postgraduate programs recently initiated at the University of the Sunshine Coast (USC), Queensland, Australia. The Masters of Integrated Coastal Zone Management, Masters of Climate Change Adaptation and Masters of Environmental Change Management are all intended to advance professional development of students in local, state, and national governments, community organisations, urban planning and engineering, resource management, property development, and other corporations. This chapter argues that skills, values, and aptitudes are advanced through 'leaning by doing' pedagogies. In the case of sustainability literacy these require an understanding of ecosystems and tools required to assess their condition. Importantly, 'leaning by doing' goes beyond the idea that core, disciplinary or technical knowledge is straightforwardly transmitted through uncomplicated processes of teaching and learning. Rather it involves hands-on activities which facilitate knowledge, skills application, and adaptation.

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Sustainability literacy can be understood as comprising: (a) understanding the need for individual and collective change to sustainable practices, (b) sufficient knowledge and skills to decide and act sustainably, and (c) the ability to recognize and reward decisions and actions favouring sustainability (Parkin et al 2004). In this, sustainability literacy may involve a singular classroom activity or, as demonstrated in this article, nested and integrated sets of curricula and pedagogical processes. In the professional programs discussed here, regional engagement and partnership arrangements enable students to locate real problems and generate real solutions. Courses deliver content information about ecosystems and their evaluation and allow students to understand issues of variability and change and the need to assess current conditions, facilities, and operational activities. For example, students learn about integrated environmental management, climatological and hydrological systems dynamics, and coastal systems. They are also familiarized with tools necessary to undertake environmental assessments and audits of facilities and operational activities; review potential effects of climatic variability and change on water yield of selected catchments; assess climate risk in relation to settlement and infrastructure or on natural heritage values; undertake coastal vulnerability and adaptation assessments.

Adaptation actions are many and varied. They can involve: technology (e.g. sea defence constructions); behaviour (e.g. shifts in choice of food); management (e.g. changes in farming methods); and policy (e.g. changes to planning regulations). They often cut across multiple activities and involve multiple stresses such as in the case of water resource, agriculture, coastal, and disaster management (Vogel 2008). Importantly, is in the application and adaptation of new knowledge and skills to these complex conditions, with a view to clarifying local problems and providing sustainable solutions, that a 'learning by doing' approach offers an important means of developing *in situ* sustainability literacy skills. Fifty per cent of coursework in the Masters programs comprise practical problem-solving projects which create ownership and increase motivation and commitment to sustainability. The integrated process is important because it facilitates dialogue, cooperation and enhances community and capacity building as well as locating educational activity in the lives and experience of students themselves. Located in the everyday world of local communities and organisations, this nested process generates the possibility of new ways of naming and acting for change (Freire 1972). The pedagogical point to be made here is that how and why we teach is as significant as what we teach and the knowledge, skills, and ability to understand and act and in favour of sustainability can be usefully generated in processes of engagement with the immediate and complex problems that beset local communities.

Climate Change and Coastal Zones

The threat of global warming and its devastating impacts on coastal communities, food and water supplies, human health and infrastructure, natural and cultural diversity, and the global economy is imminent. The Stern Review warned that failure to avert the consequences of global warning would result in a worldwide recession (Stern 2006). The Garnaut Report (2008) pointed to the physical, biological, economic, and social risks and consequences of increasing greenhouse gas concentrations, and the highlighted need for immediate action. The IPCC (2007) observed that changes to the climate were more rapid than anything the earth had experienced for 1,800 years and called for climate change adaptation and mitigation.

Worldwide, millions of people live in coastal zones and in Australia some 85% of the population live within 50 km of the shoreline. It is in coastal zones where human and natural forcing factors have greatest impact (Waterman 1996). These include:

- Rapid population growth and the accelerated expansion of settlements and the accompanying pressures on natural and production systems arising from changing land uses including urban and industrial developments
- The potential threats and risks arising from climate variability and change to food production systems, the provision of potable water, public health, infrastructure, and habitats of plant and animal species
- Biophysical and socioeconomic impacts on environmental conditions and values that can be attributed to primary and secondary industries and urban development
- Extreme natural events and unmanaged human activities that contribute to the loss of visual amenity, degradation and loss of heritage and cultural values, extinction of species and reduction in the spatial extent and quality of habitats for all life forms

Climate change is the major threat to the sustainability of natural and human systems (Kay et al 1996; May et al 1998: Waterman et al 2000). Changed climatic conditions and increasing population pose risks to biodiversity, food and water security, human and environmental health, and to patterns of settlement and infrastructure (White and Waterman 2006).

International and national responses point to the need to mainstream adaptation strategies into policy, plans, and on-the-ground actions. In turn, this has led to the need to provide new and enhanced information, knowledge, and skills, across all sectors of civil society. Professionals from a wide range of disciplinary backgrounds urgently require skills for climate change adaptation if sustainability policy, planning, and actions are to be mainstreamed. Globally too, governments and civil society are becoming informed and involved in implementing immediate measures to deal with the challenges and changes presented by climatic variability. Initiatives implemented to understand and report on dimensions of environmental change, illustrated by state-of-the-environment, sustainability and 'triple bottom-line' reporting include activities that formally monitor and report on changing conditions at national, regional, and local levels. Additionally, a number of capacity-building programmes have been initiated by government departments and agencies, universities, and training providers to address immediate professional development needs. A key barrier however, is the level of professional capability and capacity available to governments, industry, and communities.

Rising to the Challenge: An Integrated Approach

In the context of population and settlement pressures in coastal zones, and in response to the urgent need for tertiary qualified transdisciplinary practitioners, USC has developed a suite of linked, nested and fully articulated undergraduate and post-graduate programs intended to more effectively equip professionals to proactively address climatic variability, change, inherent risks, vulnerabilities, impacts, and adaptive responses especially. These are shown schematically in Fig. 1.

A strong professional development focus is provided by projects and Work Integrated Learning courses at USC that extend learning and skills acquisition to applied situations. Importantly, the programs are engaged and linked to community, government, and industry, thereby providing a robust basis for addressing specific regional and local needs, as well as advancing knowledge and skills required to address mainstreaming climate change adaptation into policy, planning, and sustainable development proposals, programmes, and projects. Conceptually, the program addresses the three interrelated areas of activity shown schematically in Fig. 2.

The fundamental research and research training aspect is supported by competitive and other grants such as from The Australian Government Department of Climate Change on the Climate Change Adaptation Skills for Professionals Program. This has facilitated connections with other universities and training providers from various industry sectors. Applied research and climate-proofing demonstration projects are delivered through consultancy services. For example, the South-East Queensland (SEQ) 'Climate-Proofing' Demonstration Project is undertaken in

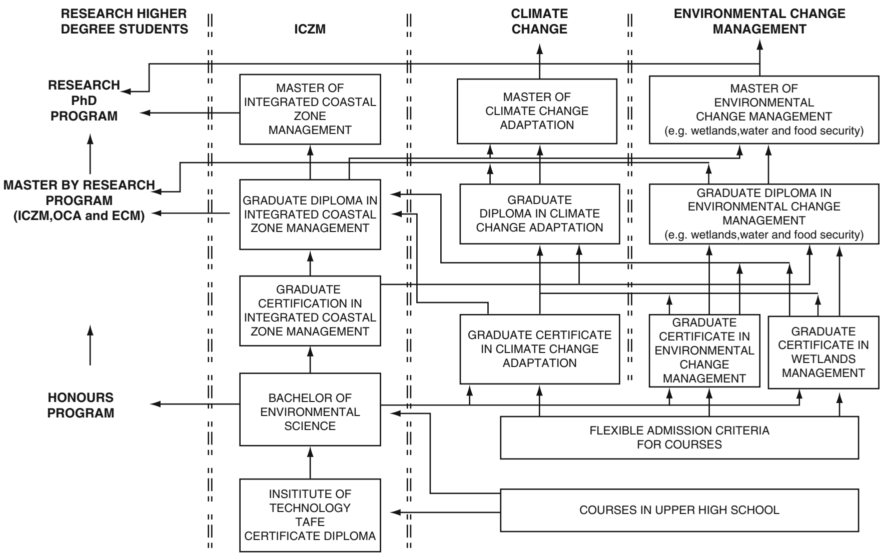

Fig. 1 Articulated professional development streams in integrated costal zone management (ICZM), climate change adaption (CCA), and environmental change management (ECM)

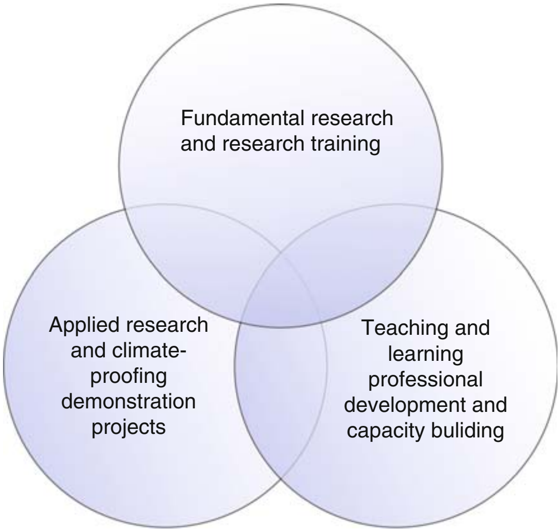

Fig. 2 Climatic and environmental change activities at USC

collaboration with two major natural resources management bodies (SEQ Catchments and the Burnett Mary Regional Group). This aspect of delivery has also forged strong links between students and staff from USC, Regional Councils and communities, resulting in the generation of a range of publicly accessible information materials and facilitated community meetings and workshops. These interlocked areas of activity are in turn underpinned by teaching and learning, professional development and capacity building delivered through a combination of accredited postgraduate programs (coursework and research), undergraduate courses, professional short courses and technical training at institutional and community levels.

Collectively, these areas of activity provide a strong basis from which to educate a new generation of professionals committed to the delivery of community-engaged action for sustainability. Additionally, they serve as vehicles for raising the public and private sector community and individual awareness, understanding and confidence necessary to meet the challenges of climatic variability and change.

Conclusion

Our present predicament is unprecedented and concerns the uncompromising facts of changes which will affect every living organism on the planet over forthcoming decades. We have in this article sought to show how the combination of regional engagement, partnerships, and project activities provide an indispensable basis for the development of sustainability literacy skills. The professional development approach described here requires flexibility and integration so that courses and programs can mix, match, and adapt a combination of frameworks, concepts, and methods (Gupta 2007 cited in Vogel 2008). Pathways to action are opened through ‘learning by doing’ pedagogies tied to real-life situations through community engagements, partnerships, and projects. In this, we suggest that the approach makes a valuable contribution to developing climate change adaption skills and understanding new dimensions of sustainability literacy.

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Chapter 7
Getting to the Heart of Climate Change Through Stories

Scott Carlin

Abstract The stories students tell about climate change will have a profound effect upon their lives. Those stories reflect broader cultural values and environmental discourses. Therefore it is important that students think critically about the stories they learn and develop their own personal climate stories. Will students respond reactively or proactively to this issue? By seeing themselves as protagonists in the story of climate change, can students become more motivated to act upon this issue? Using the concept of ecological identity helps students to redefine their personal stories and possibly resolve a key modern paradox: the pursuit of personal security undermines planetary security. Ultimately, these ecological stories must come from the heart.

Keywords Ecological identity · Environmental discourses · Spiritual ecology · Storytelling · Student activism

Introduction

In science and politics it is common to speak about climate change as a serious problem. The American Association for the Advancement of Science (2007) stated: "The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society. Accumulating data from across the globe reveal a wide array of effects: rapidly melting glaciers, destabilization of major ice sheets, increases in extreme weather, rising sea level, shifts in species ranges, and more. The pace of change and the evidence of harm have increased markedly over the last five years. The time to control greenhouse gas emissions is now." The United Nations Intergovernmental Panel on Climate Change (2007), p. 4) concluded: "Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions grew by about 80% between 1970 and

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2004. The long-term trend of declining CO_2 emissions per unit of energy supplied reversed after 2000."

Similar stories have been constructed by news agencies, governments, and scientists around the world: climate change is a serious problem; greenhouse gas (GHG) emissions must be controlled. Solutions will require significant reductions in GHG emissions, through improvements in energy efficiency, the adoption of renewable energy technologies, carbon taxes, and carbon cap-and-trade mechanisms. These solutions involve significant social changes, but leave the basic global market-based economic framework intact. For example, the widely-cited Stern Review (2007), p. xxvii concludes: "The policy tools exist to create the incentives required to change investment patterns and move the global economy onto a low-carbon path."

Environmental Discourses

Clearly there is a relationship between climate and GHG emissions. But there are other ways of framing this relationship; there are other stories that can be told. For example, climate change could be framed as an outcome of an economic system predicated upon economic growth and exploitation. From this perspective, global warming is one of many manifestations of systemic crisis (Foster 2009). A third storyline might focus on gender: how are men and women differentially responsible for (and responding to) climate change? A fourth storyline could highlight industrial nations' over-consumption of fossil fuels and the impacts this imposes upon poorer nations. Therefore, it is important that students have the ability to articulate and analyse a full range of alternative scientific explanations and policy proposals.

One mode of analysis is for students to assess the various alternative stories used explain human–environmental relationships. Dryzek (2005) has analysed ten different discourses that define environmental politics. Esbjörn-Hargens and Zimmerman (2009), p. 1 identify "more than 200 distinct and valuable perspectives on the natural world – and with researchers, economists, ethicists, psychologists, and others often taking completely different stances on the issues." Scientists working within a particular discourse make certain assumptions about the world, highlight particular values, and rely upon specific methodologies. Not surprisingly, scientists working in different academic fields or discourses clash with each other. Each discourse creates its own set of blinders; a discourse helps illuminate particular aspects of reality while simultaneously obfuscating other aspects.

In *The Skeptical Environmentalist,* Bjørn Lomborg (2001), p. 4 generated controversy with his charge that environmental narratives are often nothing more than a litany of complaints, poorly supported by data. Instead, "Mankind's lot has actually improved in terms of practically every measurable indicator." Lomborg's Promethean values and methodologies were criticized by environmental scientists (Schneider et al 2002) representing what Dryzek would term a survivalist discourse.

Whereas Prometheans prioritize technological innovation in their stories, survivalists emphasize the planet's finite and fragile resource systems. Such debates occur frequently between economists and ecologists and are very common in climate change studies and debates.

The debates are seemingly irresolvable because the two sides focus on very different aspects of an issue. For survivalists, exponential growth on a finite planet must inevitably lead to overshoot and collapse (Meadows et al 1972; Catton 1980). For prometheans, technological innovation creates a more elastic definition of natural resources. As commodity prices rise, market participants reduce their purchases of a given commodity. Furthermore, price increases spur inventions enabling society to achieve unanticipated windfalls in material prosperity (Simon 1981). Since markets are self-correcting, there is little need for government intervention. Survivalists typically disagree and argue that the government must correct for numerous market inefficiencies. For example, markets do a poor job of addressing environmental externalities, such as air pollution.

While the promethean and survivalist discourses are the most prominent in national American politics, and do not emphasize the power of everyday citizens, there are many other discourses that citizens can draw upon that elevate their role and power in national decision-making. Many leading ecological thinkers (Suzuki 1997; Orr 2004; Shiva 2005; Capra 1997) believe that our environmental difficulties stem from misperceiving the reality of our relationship with the natural world. One core element of this misperception is that modern societies lack what Thomashow (1995) calls an "ecological identity", which allows humans to acknowledge their interdependence with the natural world. An ecological world view is not only a new abstract model of how the world is constituted; it is also a visceral, emotional engagement with that world. Macy (1991) describes this relationship as "world as lover, world as self". This emphasis on interdependence is also decentering. It flattens hierarchies and raises the power that each individual has to effect change in the world. Korten (2006), p. 35 refers to this as an emerging Earth Community, which Hawken (2007) believes represents the largest social movement in history.

Subjectivity and Climate Change: The Power of Story

The language societies use to describe climate change has a powerful influence. Ganz (2001), p. 3 advocates using stories to weave communities (and social movements) together to build a better world: "Storytelling may be what most distinguishes social movements from interest groups and other forms of collective action. . . . Storytelling is how we develop individual and collective identities that define the ends we seek. . . . Storytelling is how we access the emotional – or moral – resources for the motivation to act on those ends." Can this focus on story telling empower students and citizens to think differently about their lives and their investment in climate-friendly practices, from the personal to the political?

In spring 2009, the author asked students in an undergraduate class on climate change to explore their own first-person, climate-change narratives, where they explored their own evolving life stories in relation to climate change. (This assignment grew out of a United Nations presentation by Seager (2007)). As protagonists in their own life story, what climate-related goals do these students hope to achieve? What obstacles stand in their way? Is climate change something that students expect to respond to reactively or proactively? It is important for students to think about their personal engagement with this issue and construct personal narratives that place students in the story of climate change. Below are three students' stories. The students revised their stories throughout the semester, as they learned more about climate issues and ecological discourses.

On a recent trip to visit relatives in South America, Stephanie heard local folklore about the Andes Mountains and how the glacial snows were disappearing. Weeks later she was along the banks of a small stream when she "saw life all around me, an array of birds, iguanas, trees, even the clouds moved across the sky and the morning mist seemed to sway across the stream. That's when I thought, wow this is our planet, and we are its protectors, the ones that make decisions. What kind of decision have we made so far?" As a future teacher, Stephanie wants her students to be engaged as knowledgeable and active citizens. She wants them to understand the strengths and weaknesses of past decisions and to have the proper educational foundation to make better choices.

Later in the semester, the class developed a campus-wide energy and climate action plan. It was Stephanie's idea to call the programme CARES: Climate Awareness, Responsibility, Education, and Sustainability. She wants her campus to become "a place where people have melted the ice in their hearts and joined the movement against global climate change." The melting ice metaphor comes from Angaangaq (2008), an Eskimo-Kalaallit elder from Greenland, whom the students met during a class field trip to Power Shift 2009, a climate change conference for students held in Washington, DC.

Early in the semester, James spoke about the importance of education and personal sacrifice in his climate change biography. He also spoke of the fears of living in the United States after the attacks of 9/11 and the country's preoccupation with foreign wars. At the end of the semester, James wrote, "My story has changed dramatically in the past two months. . . . It was very moving to listen to [Angaangaq's] story and to hear him speak about melting the ice in people's hearts to save us from the melting of the glaciers. . . . The idea that caring for one another and opening our hearts to others' pain and suffering can be the answer to solving the global climate crisis is something I consider very serious and important. This more than any statistic or economic plan has influenced my story and my view on climate change."

After attending Power Shift 2009, Nicole writes, "Going to the conference I did not expect to be moved spiritually at all, however I had no choice. . . . I now know that although it may not be my problem, I want my great-granddaughter to be able to thank me one day for fighting as hard as I possibly can. My climate change story has added love and hope rather than just information." At Power Shift 2009, the students had participated in a short meditation where they were asked to imagine talking with their great-grandchildren 100 years in the future. They were asked to imagine the gratitude those grandchildren felt towards the heroism displayed by people 100 years ago to dramatically transform their lifestyles so that carbon emissions could fall rapidly around the world.

At the end of the semester, the students were asked to revise their personal stories to incorporate the concept of the "ecological self", which Bragg (1987) defines as "a wide, expansive or field-like sense of self, which ultimately includes all life-forms, ecosystems and the Earth itself". According to Bragg, the ecological self: (1) experiences an "emotional resonance" toward nature; (2) perceives other life forms as similar, related to, or identical (to the self); and (3) reacts to the ecosphere with nurturance and self protection, as one would toward one's "small self". How would the students' stories change, if the very basis of their self-identity (typically based around the ego – the "small self") was now to shift toward a very different concept of the self?

Nicole wrote that, "Every person struggles with their ego at one time or another. When we are younger, our wants and desires seem even more important than our basic needs or the needs of the entire planet. As we develop into mature adults we begin to realize other people have wants and desires and other people matter. The same goes for our entire planet Earth. Each tree that is cut down is a part of us; each river that dries up is something we have lost that we will never get back. The sooner individuals accept their ecological self and believe in the truth it holds, the better off the planet will be".

"I am not a very materialistic person, ... [so] it is easy for me to turn away from my ego in some respects, [but] I still have not embraced my ecological self either. Living where I live, it is almost impossible not to destroy nature on a daily basis. Everywhere I turn people are littering, cutting down trees and burning more fossil fuels. Many people would be happy to maintain the status quo, but I am not one of them".

James writes, "A concept that has been missing from the interpretation of one's "self" can be added in one word: ecological. The concept of the "ecological self" is an essential part of living on this planet and shifting to an environmentally sustainable world. . . . This changes the idea of the protagonist in each of our individual stories. The protagonist is no longer a single person battling a single problem. Our thought processes would now include how each decision we make would affect the entire planet and all of its ecosystems and social networks. This is an intense change in one's philosophy of life: to stop thinking as an individual [and] . . . begin thinking [of the self] as an essential part of the Earth. . . . The problem that we face as individuals, as a species and as a planet may well rest on this idea of the ecological self".

And Stephanie wrote, "Before my experience at Volcano Cotacachi I was a recent high school graduate, a daughter, a sister, a girlfriend, a co-worker, an employee, a writer, [and] an artist. . . . After my experience at Volcano Cotacachi I saw myself as a resident of planet Earth and one of its protectors. Mishka Lysack (2007), p. 10 says the shift from individual self to the ecological self is a shift that requires people to view themselves as part of the Earth. [The] ecological self is how I define myself in the broad spectrum of the Earth and how I am not only part of nature, but also its protector".

These stories show that the tools people use to construct their personal biographies can have a powerful effect upon their self-perception and the types of goals that they set for themselves. Education can shape and transform personal values and beliefs. Nicole now sees climate change as a spiritual issue; it is an issue that transcends her own life and will affect the lives of many generations to come. For James, the ecological self is potentially a powerful new life philosophy. One challenging aspect of climate change is that fossil fuel consumption improves personal well-being but undermines planetary health. The students' comments illustrate that the ecological identity concept is one part of a larger set of solutions that can help societies to resolve this paradox through new practices and forms of activism.

Activism in the Classroom

Marshall Ganz argues that stories have value because "it constructs agency, shapes identity, and motivates action". Stories aim to empower. The Power Shift 2009 conference in Washington DC was an historic gathering at an historic moment in American history, with America poised to enact its first significant national climate change legislation. The goal of the conference was to help push Congress into passing that legislation. The week of the conference, House Speaker Nancy Pelosi and Senator Harry Reid (2009) announced support for switching the Capitol Power Plant from coal to natural gas. This gave the conference an early victory as the conference was to end with a large protest against the utility's use of coal.

By participating in the conference, the coal protest, and Congressional lobbying, students enjoyed a wide range of powerful ("first time in my life") experiences that gave them a new vantage point for understanding the relationship between stories and social movements. They could see more clearly that a national conversation existed among their peers at colleges across the country. They met student leaders, who had learned how to organize and lead a national conference. They felt more empowered to bring that message back to their own campus and in some small or large way try to replicate that effort on their own campus. The class developed an action report to reduce their college's future carbon emissions based upon their research of various universities: Arizona State, Buffalo, Colgate, Harvard, Yale, and Vermont.

The Ganz assignments helped the students define their class vision statement: "As students on and of the Earth, we must realize that we are at a pivotal point in our history. We can no longer live our lives without thinking about the future or the future of our planet. It is time to embrace the idea of melting the ice in our hearts. It is time to let go of our additions to technology and fossil fuels. To do this, we must have a complete shift in our ways of living and thinking.... We need to think multiple generations ahead, a practice of many native cultures" (Author 2009). This vision statement doesn't resolve the many contradictions of modern life, with its heavy dependence upon a fossil-fuel driven economy. But it is an explicit call for redirecting campus priorities so that those existing dependencies can be challenged and overcome.

In their 25-page report, the students urge the campus to create a new Office of Sustainability, replicating the work of other college campuses. This Office would be tasked with creating a carbon inventory for the campus and a plan for reducing future campus carbon emissions. The students also completed a survey of their peers, which they incorporated into their action plan. The survey was completed by 150 students (but is not necessarily representative of the entire campus population). Of those surveyed, 90% wanted the college to purchase and instal solar panels, and 78% believed the campus should pay more attention to global warming. In addition, 80% thought that global warming would have a measurable impact on their lives; 68% stated that all students should be required to have a better understanding of this issue; and 85% wanted more campus-wide education through campus posters and signage (Author 2009). The students presented the action plan and the survey results at a banquet dinner celebrating Earth Day.

Conclusions: Discovering the Heart of Climate Change

Colleges and universities contain some of the nation's highest concentrations of scientists and have historically been sites of progressive student activism. Colleges, however, are fraught with internal policies, past practices, and pricing signals that retard these institutions' abilities to reduce carbon emissions.

Despite these drags on reform, colleges and universities recognize that they must become greener institutions. While investments in energy efficiency are foremost financial decisions, universities have a particular responsibility to honour other truths: scientific findings and the ethical, emotional, and spiritual aspirations of higher education communities. The science of climate change is now sufficiently clear, so the critical question now becomes: What do we value more – money and convenience, or an ecologically habitable planet? The biologist Stephen Jay Gould (1993), p. 40 once said, "We will not fight to save what we do not love." Today's students must confront this existential question: What do they most love? And if they answer 'a liveable planet', they must learn to communicate that aspiration. In *Fighting for Love in the Century of Extinction*, Goodstein (2007), p. 77 writes that, "effective political communication comes from the heart, and the heart of concern about the impacts of humanity's climate destabilization is a spiritual connection to nature."

Early in the semester, the author's students watched a video of Angaangaq (2008). Little did those students know that a few weeks later, they would personally meet him. For some, that encounter was a pivotal moment in their semester. Angaangaq's spiritual message resonated deeply with them. Scientists might scoff at the idea that the ice in our hearts is causing the glaciers in Angaangaq's Greenland to melt, but the message is not meant to undermine scientific knowledge. Instead, the intent is to access that knowledge in a way that gives new insight into this global crisis. In Washington, DC, Angaangaq told the students that he was the first Eskimo to address the United Nations on climate change in 1972. When he returned home an elder asked him if he was heard, and Angaangaq replied yes; he had received a standing ovation. And the elder replied, "Yes, but did they hear you?"

By itself, telling stories will not overcome the many obstacles that impede the world from creating a low carbon emission economy. Stories that celebrate a newly discovered ecological identity do not resolve the tensions between the West's celebration of individualism (and human rights) and the constraints on individualism implicit in the ecological self. But the telling of stories is one of many necessary first steps. Constructing an ecologically sustainable future requires engaging peoples' hearts and creating opportunities for a wider diversity of stories to be expressed and heard. Climate change isn't a single problem or a single story; it is rooted in the multiplicity of human experiences.

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Chapter 8
Climate Change Education in the Curricula of Technical and Classical Universities

Dagnija Blumberga and Maris Klavins

Abstract Climate change education is becoming an integral part of the education in study programs at universities in Latvia offering environmental education study programs. In this article, a comparison of approaches of climate change education in classical (University of Latvia) and technical (Riga Technical University) are discussed. Requirements of the labour market are the key factors influencing study content and study methods. Therefore, consultations with major stakeholders and with academics involved in environmental education (e.g. the Council of Environmental Education and Science), may be some of the main tools to implement new concepts.

Keywords Cooperation · Curricula · Education · Universities

Introduction

Education on climate change is one aspect of a way towards implementation of education for sustainable development concepts into everyday practice at universities (Seacrest et al 2007). At the same time, the ways to discuss different aspects of climate change problems differ greatly depending on the type of study programs and approaches used during the development of study curricula (Pruneau et al 2001). The approaches used in a classical university (University of Latvia) and a technical university (Riga Technical University) to advance environmental education stressing the education on different aspects on climate change in Latvia are discussed.

Target Groups

To develop approaches for training, identification of target groups and knowledge needed in society and required in the labour market can be considered as the first step. The first questions to address are: (a) the level of knowledge about climate

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change (CC) and its impacts; (b) who needs experts on CC, and (c) which type of expertise is required in society and the labour market?

In the current situation, the labour market is the main driving force influencing ways of restructuring the educational system and supporting the appearance of new study programs (Pruneau et al 2006). As a tool for identification of trends and requirements, labour market surveys and discussions with experts can help to find answers to the identified problems, as well as to forecast actual needs in the future. To get the feeling of the processes in the labour market and ways of restructuring study programs as an efficient tool, self-assessment studies of study programs in Latvia are used as well as accreditation by international expert teams every six years. Additional important sources of information about actualities include regular consultations with experts in the field.

The requirements towards training on CC can be structured depending on the following levels:

1st level: General information about climate change
2nd level: General information about climate change and consequences of it
3rd level: Understanding of societal responsibility and need to mitigate and adapt to CC
4th level: In-depth basic studies of CC, including modelling, studies of impacts at local and regional level
5th level: Expert level – consulting, participation in Kyoto flexible mechanisms: emission trading or joint implementation schemes

Despite the information in the mass media being relatively wide and some aspects of the CC issue being discussed at school, there is still a clear need to address the issue at university level with systematic and systemic information on CC (1st, 2nd level of CC education) (Cordero et al 2008). The third to fifth levels can be related to training of experts (specialization requires allocation of significant space in the study programs or even specialization at higher study level in CC). Key components are management and decision-making skills which allow people to achieve the aims of climate change education.

Activities

Education for climate change is gradually changing from a level of dispersed activities to a more or less unified system and tight cooperation between academics, universities and stakeholders (Wittneben and Kiyar 2009), who all play a key role in the decision-making process (Fig. 1).

The Latvian Council of Environmental Science and Education (LVZIP) plays a key role in the structuring of the cooperation process. This council can be considered as quite a unique body as far as it involves representatives of major universities (usually involved in quite harsh competition for students and leadership amongst environmental educators) and leading environmental scientists. If such a combination

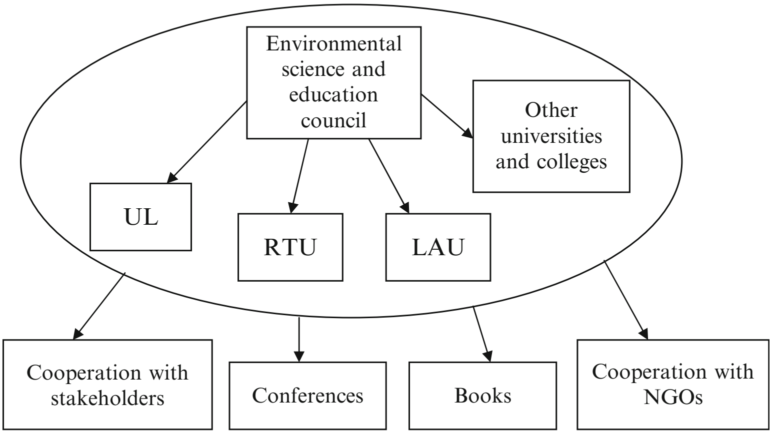

Fig. 1 Activities of universities for development of climate change education

is usual for academic councils, then active involvement of stakeholders and social partners (representatives of ministries of Environment, Education and science, Agriculture, Regional Development and municipal issues, as well as representatives of private business) put an additional dimension into the academic discussion, deepening not only the content of the discussion, but also widening the impact of the decisions and ensuring an outreach effect of the obtained decisions.

The cooperation between universities involved in environmental education is based on joint activities, participation in activities of LVZIP and joint projects under the umbrella of LVZIP. Amongst the deliverables from informal and formal cooperation on the advancement of climate change education and environmental education in a wider sense, mention can be made to joint textbooks and chapters in monographies. In addition, the joint organization of conferences and projects may help to place climate change education more centrally in the educational system (see Fig. 1).

Not only are universities organizing research conferences dedicated to analysis of differing aspects of climate change, but academic conferences are also of importance where the process of reorganization of the educational system in Latvia are a key element on the agenda – a way towards sustainable education, also including education for climate change. As a significant result of this cooperation, textbooks are written by professors of University of Latvia and Riga Technical University dedicated to different aspects of climate change. At the moment, education in climate change for the first and second levels of climate change is reasonably well supported with study literature and this can be considered a good sign for progress in the future. To structure the efficiency of activities by universities towards the implementation of climate change education, an evaluation matrix concept has been used, identifying the type of activities and their impacts, effectiveness and intensity of required actions. The results of the evaluation of activities are summarized in Table 1.

Table 1 Results of evaluation of activities of universities for the development of climate change education (5 – higher value; 1 – lower)

Activity	Relevance	Efficiency	Intensity
Conferences	5	3	3
Books	4	3	3
Cooperation with NGOs	3	2	2
Cooperation with stakeholders	4	4	5

Unless the judgment on the impact of activities has a high level of subjectivity, there is a doubtful consensus on the statement that the major impact on the development of education for climate change has cooperation from stakeholders.

There are in any case many factors which need to be considered in introducing climate change aspects in university programmes both in a classical university (e.g. the University of Latvia) and at technical universities (e.g. Riga Technical University).

Curricula for "Generalists"

The "generalists" who have the necessary skills and theoretical background in the wider sense of environmental education are needed not only as experts, but as persons with a wide educational background and motivation to go deeper in one or another direction of studies – to obtain specialization. From this perspective, climate change studies have to be seen in the context of education for sustainable development. Key positions in the curricula for "generalists" do have development of systems understanding and management skills in combination with general education on environment. According to this concept, the key positions in the first years of the studies have basic natural science courses, with an introduction to the main areas of environmental science in later years and specialization in respect to thesis work and selection of narrower field of studies in later years. Training of "generalists" gives the knowledge on theoretical background of climate change, mitigation and adaptation problems, but in later years several aspects of climate change modelling, development of adaptation approaches are stressed.

Directions of Development

To achieve sustainability, there is an evident need for reorganization of the study programmes, including their possible internationalization. The suggested changes in curricula of study programs include development of study courses offered to international students with a strong emphasis on advancement of environmental management skills.

Curricula for Professionals

Professionals are persons who know how to implement climate policy and achieve relevant aims in the restructuring of society and production. On the specialist's level we would like to see the creation of a certification of environmentalists as professionals capable of managing climate issues in companies, local authorities and other places.

Existing Situation

Presently in Latvia a degree in environmental science at B.Sc., M.Sc. and PhD level can be obtained at Riga Technical University and University of Latvia. The major difference lies in the approach of structuring of the curricula providing classical education (at University of Latvia) and technical education (at Riga Technical University). The study programme at University of Latvia is aimed at development of "generalists" in natural sciences with a strong background in environmental science at Bachelor level, and advancing research-based education at MSc and PhD levels with specialization in several branches of environmental science. At the same time at Riga Technical University the education has strong emphasis on energy production, energy-saving, and climate technologies.

The education on climate change is done using the so called "dispersed climate change study approach" (Fig. 2). This approach includes use of a modular course structure. Each of the study courses deals with a separate aspect of climate change, but together each module serves to deliver a specific aspect of climate change, but all together the study programme provides a general view with specific aspects on the issue. Module "A" includes traditional environmental science study topics (environmental policy and economics, environmental technologies, cleaner

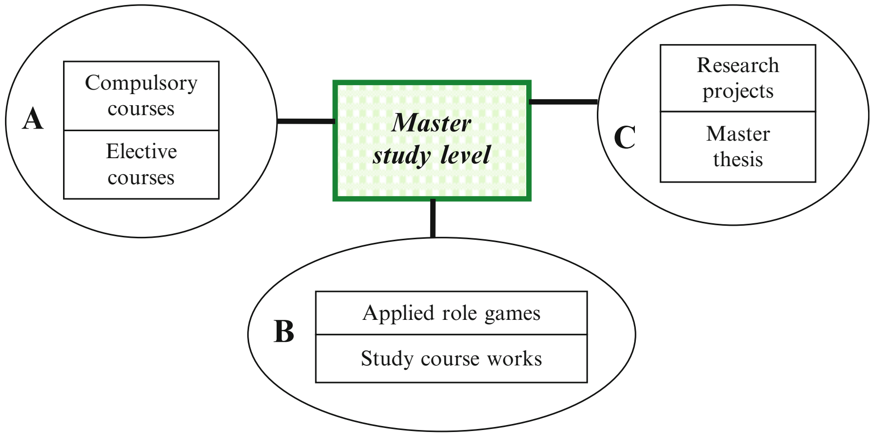

Fig. 2 Dispersed climate change study approach in Riga Technical University

production, energy technologies, environmental protection problems), as well as freely electives (environmental impact assessment, life cycle analysis, and others).

Module "B" includes not only traditional study forms, during practical classes doing independent studies, calculations, audits of enterprises, but also using games as tools of studies. A special place is allocated for the engineering aspects of the emission trade and flexible mechanisms in this respect. For example, the course "cleaner production" includes the audit of eco-efficiency and energy efficiency of businesses, with students attempting to give recommendations for an enterprise on how to increase efficiency of production at the same time as increasing environmental efficiency. In the module "B" coursework is also of major importance as far as during this stage of the study process students gain necessary practical skills.

Module "C" involves deeper consideration of issues currently affecting Latvia and neighbouring countries. The students have the possibility to be involved in finding solutions to current problems in businesses. The possibility to participate in research projects and cooperation between state authorities and academia is also of importance. For example, students actively participate in the elaboration of energy efficiency improvements and renewable energy strategies (for the next decades), developing action plans which are based in development of climate-friendly technologies in Latvia.

Case Study

Each year, the content of the module B is supplemented with new, creative ideas, mostly arising from research or applied projects. For example, elaborating plans for development of environmentally friendly approaches for development of the energy production sector in Latvia, the academics at the Riga Technical University found out that Latvia can reduce the emissions of greenhouse gases from energy production process by approximately 2,000,000 tons/year CO_2, replacing fossil fuel sources by renewable energy resources, increasing the share of wood in the production of energy balance.

This experience has been shown to advance and further improve MSc and PhD level study courses offering for students' discussion the role play: "Latvia has huge wood timber resources, but in the energy sector the renewable are still used comparatively little. Why?" To structure the discussion for lecturers and students the scorecard questions were prepared to organize the discussion:

1. Vertical dimension of the discussion
   (a) Short introduction to the problem. Identification of aims and targets of the discussion. The role of each partner in the discussion. The assessment of timber resources and discussion about existing approaches of their usage. The validity of the data gathered.
   (b) Technological solutions for the use of renewable energy resources for the production of energy from fireplaces to wood stoves to large-scale energy production in cogeneration process

   (c) How Latvia can reach EU targets of the use of renewable energy resources and reduction of GHG emissions. Forecast and forward-looking approach?
   (d) Impacts of the use of timber for energy production on the mitigation of climate change. Flexible mechanisms of the Kyoto Protocol?
2. Horizontal dimension of the discussion. The thematic areas of the discussion:
   (a) Legislation influencing use of energy sources
   (b) Engineering aspects of the replacement of fossil fuel with renewable timber
   (c) Economic financial policy. Investment policy. Roles of information and education.
   (d) Climate change and other environmental impacts, e.g. air pollution by timber burning.

The participants of the discussion are split into five groups and after every 15 mins they change the topic of discussion. Each thematic chairperson of the discussion prepares minutes. The participants of the discussion afterwards sum up the ideas on what should be done in the sector of energy production to develop a sustainable system of energy production as well as to reduce the impacts on the environment and climate change. Final discussion results in the preparation of the conclusions are put on the homepage of the university and sent to responsible and interested persons in the Ministry of Environment and the Ministry of Economics. This approach supports development of a multilayered and well-structured discussion, but at the same time the stakeholders are offered new ideas. However the main benefit may be related to the improvement of the study content and engagement of students in an efficient knowledge-gaining process, at the same time supporting skills of teamwork and the ability to discuss ideas.

Conclusions

The ways to discuss different aspects of climate change problems differ greatly depending on the type of study programs and approaches used during the development of study curricula. The cooperation between stakeholders and academics is of major importance in the development of the study process. Close links with academic research is of importance in the development of innovative learning methods in climate change education.

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Chapter 9
Interdisciplinary and Interfaculty Approaches in Higher Education Capable of Permeating the Complexity of Climate Change

Roland Hergert, Volker Barth, and Thomas Klenke

Abstract Climate change is known for its complexity. The fourth IPCC assessment report (AR4) compiles multifaceted facts and suggestions relevant for decision-making. This report is thus an ideal basis for educational activities aimed at addressing climate change comprehensively. Teaching an integrated view on climate change, however, requires a proper teaching method in order to enable students to (1) understand crucial climatic processes and impacts on the Earth system, (2) comprehend core elements of adaptation and mitigation strategies, and (3) discuss and even innovate strategies for different societal actors. We designed and applied an approach where student working groups addressed different aspects of the IPCC AR4 (Governance, Ocean and Coasts, Economics and Renewable Energy). Each group consisted of five to nine students from diverse backgrounds, ranging from economics and social sciences to environmental scientists and physicists. The groups were supervised by an expert scientist. The task of the groups was to prepare a presentation on the group's subject suitable for an interdisciplinary audience. External experts gave scientific and methodological background information. Outcomes from this one-term course comprised video films, presentations and material for further outreach. Students and lecturers shared the invaluable life experience of the difficulties of interdisciplinary cooperation and how to manage them.

Keywords Climate change · IPCC · Interdisciplinary study programmes · Key competencies · Higher education

Introduction

The complexity of global environmental problems as well as the associated uncertainties challenges traditional decision-making processes in society, politics, and business. The role of science in addressing these problems is twofold: On the one

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hand, scientific research is required to estimate the size and scope of the problem, which is often a multidisciplinary and interdisciplinary endeavour, which not only involves natural, but also economical, social, and political issues (Siebenhüner 2003). On the other hand, the multidimensional picture that results from this research needs to be aggregated and broken down to become manageable for decision-makers in politics and companies (Siebenhüner 2002; Biermann 2002). This is usually done in the form of reports, which collect and aggregate existing research results. Prominent examples are the reports of the Intergovernmental Panel on Climate Change (IPCC, 2007a, b, c, d) or the flagship reports of the German Advisory Council on Global Change (e.g. WGBU 2007). Besides the implicit judgement associated with selection and aggregation, these reports are designed to advise policy and thus contain explicit assessments, making them (partly) highly controversial and political texts.

Dealing properly with assessment reports on global change issues increasingly becomes a key competence in many employment fields (OECD 2005; Bormann and de Haan 2008). In order to understand and interpret scientific reports for adequate use in various contexts requires a set of abilities that ranges from a comprehensive knowledge of relevant aspects and findings from various fields and a knowledge base of tools, theories, and models used in different disciplines to the skills to integrate multiple perspectives. It is therefore a challenge to modern higher education to train and enable students to understand and transfer those report findings to society and to adequately translate them to different societal actors. This contribution firstly introduces the design of a teaching module that aims at providing students with a broad overview and the competence to solve complex problems through a multi-perspective course of studies and secondly evaluates the experiences of course designers, teachers, and students in interdisciplinary learning. Finally, it is demonstrating that the topic of climate change is a good exercise to handle complexity, uncertainty, and interdisciplinary cooperation.

Idea, Concept, and Objectives: Interdisciplinary, Interfaculty, and Interactive

It was the idea to design a course that conveys two main competences: the handling of complex scientific information and the interaction with different disciplines/perspectives. Due to its prominence in politics, economy, and science, the 4th IPCC assessment report (AR4) was chosen as the learning platform and information pool to give a comprehensive understanding of the complex aspects of climate change and to train interdisciplinary interaction.

In order to develop the course outline according to the students' interests, students from different disciplines were asked at a relatively early planning stage about their favourite topics related to climate change. The suggestions of about 70 students covered the following areas of interest:

- Models, integrative modelling, and scenarios and scenario techniques
- Scientific versus social adaptation strategies (spaces for interaction between nature, economy, and politics
- Scientific versus social theories of change (resilience, tipping points. . .)
- Societal learning perspectives, societal knowledge generation, and handling of ignorance
- Economic theories and concepts on climate change (carbon trading systems, efficiency, and consistency theories. . .)
- Renewable energy technologies (market integration, political framework)

It is obvious that no single lecturer alone would be able to address all issues on this list with sufficient expertise. The next step was thus to find lecturers and academic tutors to meet the students' interests. The challenge was to find a pragmatic solution between desired content, availability of staff, research interests, and expertise of lecturers and administrative regulations. In particular the last point turned out to be a major source for time-consuming coordination efforts (see Section II for more details).

Ultimately, the group of lecturers comprised physicists, geoecologists, economists, and political scientists, who were all involved in defining the contents of the course. The group identified the following set of questions, which were considered to be central when addressing the IPCC report:

- What kind of new societal learning techniques and governance structures are needed in the face of climate change? (Interaction/interrelation of science, politics, and economy)
- What are the main impacts on natural systems and how are they modelled? (Restricted to coastal zones for tractability reasons.)
- What kind of economic concepts are discussed to adapt or mitigate climate change?
- What kinds of new technologies (restricted to energy supply) are available to cope with climate change?

These four questions led to a course design that centred around four different working groups, where students from different disciplines would work together on one of the questions (see Fig. 1).

The course was structured in three phases. In phase 1, students were introduced to the course and its concept as well as the background and the history of the IPCC and the previous assessment reports. At the end of this phase, the students were asked to assign themselves to one of the four working groups. Phase 2 was then devoted to work within each working group, where students were asked to explore the respective lead questions in a self-organized manner and by interdisciplinary interaction between the members of the working group. One or two lecturers were assigned to each working group to provide help and guidance to the students in case of problems. Additionally, cross-cutting issues and themes that appeared to be relevant for more than one working group were presented in lectures that were given in regular plenary sessions throughout phase 2. The course concluded with a

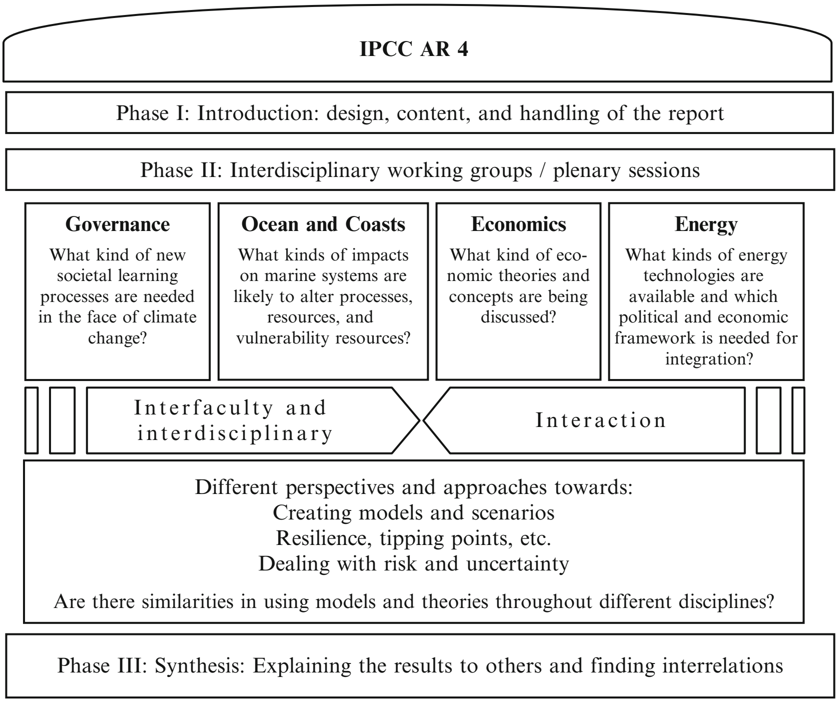

Fig. 1 Design and content of the course

synthesis of the working group results in phase 3. Here, the task of each working group was to aggregate and present its findings and results to the other working groups and the lecturers. The format of this presentation was not prescribed in advance.

The challenge for the students throughout the course was thus twofold. On the one hand, they needed to acquire, select, and interpret scientific information that was arbitrarily alien to their original discipline. On the other hand, they were asked to process and present this information and their own findings to students of other disciplines. Mastering this challenge requires four skills with varying levels of social and technical competence, which are displayed in Fig. 2. Handling a "mega-study" like the IPCC report is good training to achieve these skills.

Implementation: Interdisciplinary Teaching in Disciplinary Cultures

The IPCC course was designed as an interdisciplinary lecture that was open for students from all faculties and aimed at providing them with a general application-oriented competence, which is essential and necessary for various occupational fields.

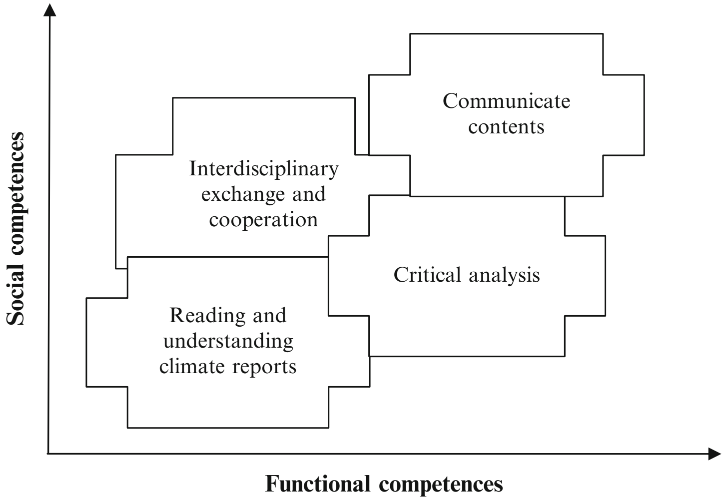

Fig. 2 Objectives for the methodical-didactical approach

Implementing an interdisciplinary course for such a broad audience within a university culture that is organized along disciplinary faculties turned out to be a major challenge in designing and managing the course. Since environmental and sustainability topics in research and teaching have been a central focus at the sampled university since its foundation, we initially assumed that setting up the IPCC course would be relatively easy. In fact, finding lecturers turned out to be relatively easy due to personal acquaintances within various internal research networks and collaborations. Despite these networks, setting up an interfaculty teaching project raised a whole host of requests on how the credit points obtained in the IPCC course would be credited for the individual degree programme of each student. This became particularly important in cases when students decided to do their course exams with a lecturer who was not assigned as a teacher in the student's faculty. All these problems had to be resolved individually, which required a high degree of personal involvement of the course organisers, which reflects the strong inertia and rigidity that still resides within the administrations of faculties and the university as a whole.

With respect to teaching, we noted a strong level of commitment. No less than eight lecturers from physics, geoecology, economics, and social sciences gave stimulus presentations on cross-cutting issues that were of interest for more than one working group and hence were held in plenary sessions. These lectures were designed to trigger further questions and show interrelations between disciplines and were followed by discussions and group work. Reported and discussed topics were:

- The IPCC as a case study for societal learning processes and innovative governance structures
- Models and climate research

- Economic instruments and concepts in the climate debate: emission trading systems, efficiency, and consistency theories
- Renewable energies – technologies and political frameworks
- Terrestrial hydrological cycle and sea-level rise
- General adaptations and mitigations strategies for climate change

Students' commitment in general was also high, despite the initial uncertainties with respect to credits and workload. One widespread motivation for students to join the course was to get information and knowledge on climate change in a more coherent and less fragmented way than in usual (disciplinary) classes, which generally focus on isolated aspects of the climate debate and often fail to explain linkages and interrelations.

Reflection: Transfer of Knowledge, Skills, and Competences

This course was a unique and novel experiment in two ways: it was the first time at the University of ###*veiled for anonymity*### that lecturers from different faculties taught together in one course, which, secondly, comprised students from almost all faculties within the university.

Feedback was given in two ways: students used the common feedback channel via the university intranet, while lecturers were asked to fill in a more detailed questionnaire. In general, most respondents welcomed the experience per se as well as interesting scientific insights related to climate change. On the other hand, besides some minor organizational deficits, it was frequently reported that the focus of the course had shifted away from the IPCC report towards the general topic of climate change.

In hindsight, this was due to the very structure of the IPCC report itself, which appears to be not well suited as a guideline for a course with undergraduate students. The global scale and scope as well as the level of detail given in the IPCC report counteracts the students' need to get an introduction to climate change together with locally confined examples. It turned out during the course that many students still lacked the basic knowledge to understand and classify much of the content of the IPCC report. These gaps in knowledge had to be filled during the course, which therefore shifted to cover topics like climate change impacts on coastal zones that were much more descriptive and thus more comprehensible by students than others, like governance or climate models. The drawback of this was that the IPCC report as such shifted out of the main focus (see Fig. 3).

In the following we will discuss how this shift in focus affected the methodological-didactical objectives from Fig. 2.

Reading and Understanding Climate Reports

Although work with the IPCC report wasn't as pronounced as originally planned, its essential elements, design, assumptions, models, and scenarios were presented and

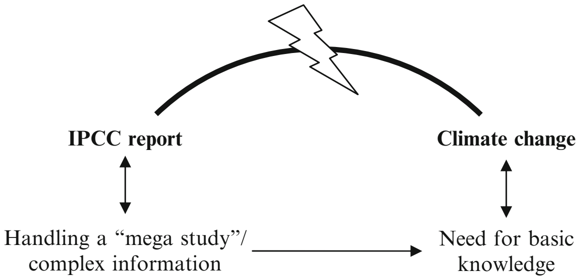

Fig. 3 Shifting dramaturgy of the course

discussed. Differences of modelling and political purposes were highlighted by the cross-cutting lectures, which also touched upon other assessment reports like the Stern report (Stern 2007) or the WBGU flagship reports (e.g. WGBU 2007).

Critical Analysis

While elements of critical analysis of assumptions and conclusions were already included in the plenary discussions of the cross-cutting lectures and the working groups, it was the core issue of the discussions within the working group on governance. The students discussed the arrangements at the science policy interface and the experiences that were made during the past few years. What kind of learning and change processes occurred in the procedures of the IPCC and what were the triggers? How strong is the relationship between the IPCC AR4 and the political decisions? Have there been effects on political decisions?

Interestingly, particularly students from the natural sciences had a strong interest in political questions, which led to an intense interdisciplinary interaction and exchange between the students in that group. Results from that group covered a self-made video film imitating political discussions and scientific consulting as well as an empirical survey among regional politicians about their perception of the IPCC findings and climate change topics.

Interdisciplinary Cooperation and Modes of Communication

The different working groups consisted of 10–15 students from various disciplines, but interdisciplinary learning was not as strong as desirable. Many groups delegated disciplinary issues to the students studying the respective subjects but failed to discuss these issues within the groups, so that the interaction of different disciplines often became low. However, since the final presentations had to be given in plenary there was still some requirement to reflect the results of the working groups to an

Problems/challenges	Recommendations
Administrative	
Different examination regulations	Early discussions and agreement with the different examination offices
Organizational	
Need for collaboration of experts from various faculties – micropolitical conflicts about resources	Collaborate with open-minded persons who are interested in innovating experiments
Teaching	
Different levels of knowledge	Cautious mix of BA and MA students; careful tailoring of work packages
Reluctance to switch to other disciplines	No individual choice of working groups; precise tuning of student's role in group and exercise
Different disciplinary languages	Training in interdisciplinary groups
Language skills (English)	Mix of German and English teaching subjects
Thematic focus	
Complexity	Concrete "real world" case studies

Fig. 4 Problems and recommendations for interdisciplinary teaching

interdisciplinary audience. Most presenters picked up that opportunity and at least tried to present their findings for a broader audience.

The most important barriers and challenges the planning team, lecturers, and students of the IPCC course met are summarized in Fig. 4.

Conclusions: Barriers of Interdisciplinary Teaching and Recommendations

Our interfaculty one-semester course on the IPCC report revealed a number of experiences. First of all, students prefer to stay within their discipline, the exchange with other disciplines did not take place in every working group. Switching to another perspective and translating findings to non-experts is both an arduous and a difficult task, and is thus likely to be avoided. It requires much more time, assistance, and guidance than we initially anticipated. Planners and lecturers in similar courses will have to pay much more attention on how to achieve interdisciplinary exchange in student's working groups, students' self-responsibility and a mix of formal and informal learning settings (Barth et al 2007).

One of the most powerful obstacles in implementing an interdisciplinary course is the rigidity of examination regulations of disciplinary study programmes. Realizing interdisciplinary courses on a broader scale would be much easier if there were flexible slots within degree programmes in order to avoid having to find underhand solutions on an ad hoc basis. To that end, the existing leeway offered by the

Bologna reforms should be used more widely and courageously when study programmes are (re)designed.

Again, we want to emphasize the importance of carefully selecting the topic to work on. Sustainability and environmental issues are well known for their complexity and often these issues are perceived as too abstract, too broad, or as lacking theoretical background (Leal Filho 2000). In our case, the large-scale framework of the IPCC AR4 was too confusing and there is a lack of real-world case studies (Steiner and Posch 2005). A more focused study covering fewer topics and/or fewer regions might have been more appropriate.

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Chapter 10
The Campus as a Classroom: Integrating People, Place, and Performance for Communicating Climate Change

Millie Rooney and Jennifer McMillin

Abstract A university campus has the potential to accomplish much more than simply providing the infrastructure in which students and staff carry out the business of education and research. The campus itself can be considered a classroom where the lessons of responsible citizenship and environmental stewardship are modelled on a daily basis through corporate behaviour, campus design, and community engagement. This chapter presents a series of case studies from the Australian National University that illustrate how a university can educate its community about climate change and a range of interrelated environmental issues.

Keywords Campus sustainability · Communication · Community engagement · climate change · Corporate behaviour · Environmental management · Universities

Introduction

When dealing with the challenges of campus sustainability, it is easy to define a university in physical terms and to establish corporate goals relating to improved processes and efficient infrastructure. In practice however, a university is also a community of people and it is this community that forms the classroom in which knowledge is built, skills are developed, and fundamental changes are negotiated. John Henry Newman aptly described this community in saying "the general principles of any study you may learn by books at home; but the detail, the colour, the tone, the air, the life which makes it live in us, you must catch all these from those in whom it lives already" (Newman 1856, p. 13).

The importance of both the social and physical context is at the heart of the campus sustainability programme established by the Australian National University (ANU). The ANU Environmental Management Program, known as ANUgreen, is broadly based and addresses each of the issues common in corporate environmental

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strategies, as will be discussed below. However, in addition to this, the underlying intent is not only to manage environmental impact, but to educate a community who will influence corporate values and produce graduates who will foster change beyond the university community.

The ANU campus is located in Canberra, the Australian national capital, on a 145 ha site. The university community is made up of approximately 13,000 students and 3,600 staff across a wide range of research and teaching disciplines. As a consequence, the campus is a large consumer of resources in the region. As the region is an area of decreasing annual rainfall within a country where the primary source of energy is coal, managing consumption becomes all the more important. This has set an environmental challenge of matching corporate performance with the academic mission and integrating the two such that they inform each other. Taking on this challenge from its launch in 1999, the ANUgreen programme has fostered organizational and individual commitment that has reduced consumption significantly in the last ten years, despite increases in both population and building stock (see Fig. 1).

As a result of the ANU Environmental Management Plan's implementation, the environmental footprint of the ANU is decreasing, even though floor area and population continue to grow.

This success can largely be attributed to the development of the Environmental Management Program and a strong commitment by university leaders to improve environmental performance and support sustainability initiatives. Since 1999, ANUgreen has been responsible for implementing and developing the campus Environmental Management Plan (EMP). ANUgreen is located within the Facilities and Services division and its key themes include energy and greenhouse management, water, waste and recycling, biodiversity and sustainable landscapes, green

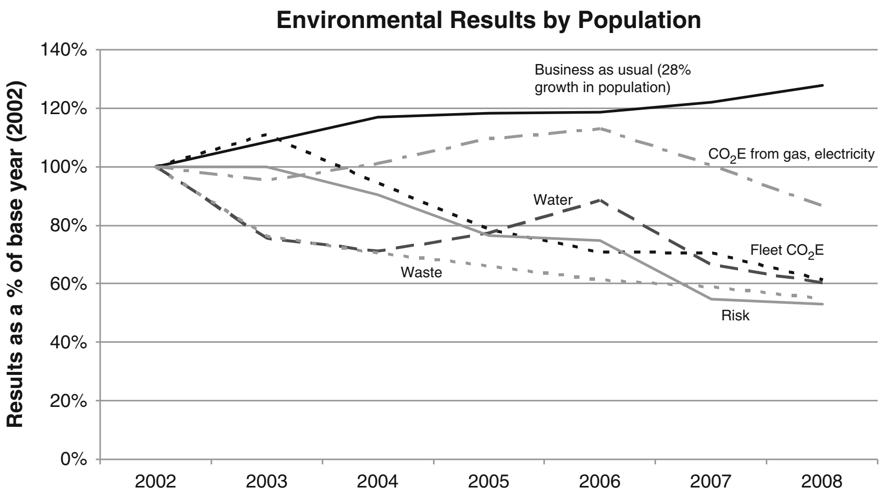

Fig. 1 Environmental Results by Population

buildings, sustainable transport, environmental risk and pollution control, and community engagement. A key element of the EMP is its holistic approach to campus sustainability, with corporate activities integrating with academic pursuits. The plan is updated every three years, with achievements against targets monitored and measured annually. The end result has been the progressive move towards mainstreaming of environmental management into decision-making and organizational values of the university.

ANU has been widely recognized for its skill in both achieving environmental targets and in communicating the message of sustainability to a range of stakeholders. Fifteen local, regional, national, and international awards have been received for sustainability outcomes including the inaugural International Sustainable Campus Network (ISCN) Excellence Award in 2009.

As a higher education institution, ANU has an obligation to set an example in its practices and to educate its graduates for environmental literacy. This chapter aims to make clear the way in which ANU and ANUgreen have sought to establish the social and physical environment in which this happens. In conjunction with a strong environmental focus within facilities management and established partnerships between practitioners and academics, many excellent academic courses exist which contribute to an understanding of climate change and environmental management, however they are beyond the scope of this paper. For further details on innovative academic programs with a sustainability focus, see Carpenter and Dyball (2006).

The chapter has been divided into three sections, *People*, *Place* and *Performance,* each with a series of case studies that highlight how sustainability is communicated to the campus community. *People* provides examples of programs aimed at challenging individual behaviours and encouraging community members to engage with sustainability initiatives. *Place* shows the value of effectively managing the built and natural environment for sustainability and how this sends a message to staff and students about the university's priorities. *Performance* highlights the ways in which resource use can be managed in sustainable ways and the importance of community engagement in achieving outcomes.

The chapter will begin with *People* and examples of programs that encourage students and staff to engage with the issues of climate change and to act on that information. Case studies include the Sustainability Learning Community, a network of students and staff that promote action for sustainability outside of the classroom setting; the SEE Sustainability at Work Green Office Program, which provides resources and support for staff to promote changes in their workplace; and the Timely Tredlies departmental bicycle fleet which reduces vehicle use on campus and promotes engagement with the campus landscape.

Under the heading of *Place,* the Green Loan Fund, a A\$3 million interest-free loan programme, will illustrate a range of initiatives that have served to reduce the environmental impact of campus infrastructure and technologies. While the Green Loan Fund focuses on the built environment, Urban Biodiversity Programs will demonstrate how landscape performance can be improved while communicating the value of sustainable landscapes to the campus community.

While all case studies in this chapter illustrate programs that have reduced campus environmental impact, some programs yield very specific and easily measurable *Performance* outcomes. The Campus Organic Recycling Program has significantly reduced waste to landfill and has effectively communicated the importance of individual actions. The Campus Furniture Redistribution Program is another example of noteworthy performance outcomes.

The case studies presented in this chapter should be seen as part of a holistic strategy: the integration of *People, Place* and *Performance* and the creation of a classroom from “the colour, the tone, the air, the life” of the university. The university’s success in communicating for climate change has been the direct result of its ability to utilize the entire campus as a classroom for teaching and communicating the principles of sustainability. By firmly linking *People* with *Place*, in order to improve *Performance*, ANU is strongly placed to maintain its position as a global leader in communicating the need for action in relation to global climate change.

People

The role of *People* in the Environmental Management Plan is to ensure that the entire campus community, including undergraduate and research students, general staff and academic staff, is actively involved in pursuing sustainability goals. The goals for *People* are to increase awareness, foster engagement, and celebrate environmental management successes.

Across campus, there are numerous examples of collaborations between practitioners, academics, and students which have provided an educational outcome while also achieving campus sustainability goals. The campus sustainability office itself is an example of this holistic approach – the ANUgreen team consists of staff from technical, administrative, and academic fields. Each brings a perspective formed from their own experience, which when combined with that of others provides a uniquely responsive group capable of meeting the challenges of a campus sustainability programme.

Within this section, the case studies demonstrating these strategies include the Sustainability Learning Community (SLC), the introduction of a green office program (SEE Sustainability at Work) and the Timely Tredlies Program providing bicycles and infrastructure for green commuting. These exemplify effective community engagement strategies for collaborating with each stakeholder group on campus and achieving sustainability outcomes at a university.

The ANU Sustainability Learning Community

One of the key communication channels for promoting sustainability-related events, ideas, opportunities, and information to the ANU is the Sustainability Learning Community (SLC). A learning community is a group of people who share common interests and who are actively engaged in learning together from each other. The SLC is an informal extension of the educational process which recognises that students can learn from each other by collaborating on projects that link classroom theory with practice. While interest in sustainability is a key element of the group, not surprisingly, membership is highly interdisciplinary, allowing students from a range of undergraduate programs to broaden their educational experience and build their ecological literacy. The Sustainability Learning Community was established in 2005 as a partnership between ANU-green, Bruce Hall (a campus residence) and The Fenner School of Environment and Society as an attempt to bring together interested staff and students outside of the classroom context and provide them with meaningful and practical sustainability experiences and skills.

This community-based approach is effective because sustainability education is most successful when students are able to make a connection between knowledge of environmental issues gained in a classroom and personal responsibility for those issues. This is not always a simple connection to make as many environmental issues are global in scale and students may feel concern or distress about a situation, but may not know how change the situation. Intellectual information about environmental problems is not usually enough to stimulate behaviour change; rather, meaningful experiences with the environment and a sense of connection to ecological processes are needed to induce action (Maiteny 2002). One of the biggest challenges then of educating for sustainability is helping students to critically assess their place in society and the ramifications of their actions (Bauer and Lewis 2000). As such, a process of education including experiential and inquiry-based learning, like that offered by the SLC, assists students in developing both a connection to their immediate environment and skills for solving problems they might find there.

The Sustainability Learning Community brings people together primarily through a mailing list of over 1,000 members with a variety of interests and skills. Staff and students join the SLC in order to receive information on sustainability-related events and opportunities on campus and can become more directly involved in a particular area of interest. The Sustainability Learning Community is responsible for the following initiatives:

- The campus organic garden
- The Great Green Debate, an annual World Environment Day dinner and debate
- Support of student green groups in ANU residential halls and colleges
- Management of the ANUgreen Sustainability Internship Program
- Earth Hour celebrations
- Celebrate Sustainability Day
- Sustainability tours and workshops

Selected initiatives will be explained in more detail below, however all have served to bring people together in the spirit of community building, communicating information on climate change, and bringing about relevant and meaningful changes to behaviour.

Green Shield Competition

Through the activities of the Sustainability Learning Community a strong network of communication and enthusiasm has developed. One of the most significant achievements of this network has been the development of a strong working group of students motivated to reduce the environmental impact of residential halls and colleges at the ANU. With the support of ANUgreen, campus academics and the network of enthusiastic volunteers, these students have initiated the introduction of a Green Shield Competition, an annual contest between campus residences to reduce energy consumption and carbon emissions. Students seek to do this by:

- raising student awareness of consumption and its broader effects;
- informing students about ways to reduce energy and water consumption; and,
- providing students with incentives to conserve through competition with other residences.

Measurement for the competition is a comparison between total consumption of energy by the residence in the designated period in 2009 compared against a baseline from the previous year. The residences are then ranked from first to last for energy consumption, with the greatest percentage decrease in consumption winning the competition.

Details of energy and water consumption for the baseline year are provided to the students before the competition so that they can set goals for their student bodies.

An important aspect of the competition is informing the resident body at each residence about the issues surrounding energy and water consumption, and then motivating residents to change their behaviour. The way in which these activities are conducted is the responsibility of each residential student green group, although information sharing is encouraged. The competition proved to be a highly successful programme for communicating and promoting action for climate change, using the university environment and real-life data as the context for learning.

Campus Organic Garden

The Sustainability Learning Community began the ANU Organic Garden in 2006 as another way to utilize the campus as a classroom. The garden is coordinated by a paid SLC member who manages the volunteers, facilitates weekly working bees and maintains the garden website and blog. Staff and students are welcome to drop into the garden during set weekly work hours during which the planting, weeding, and harvesting is done and information and skills are informally exchanged. Another way in which the garden facilitates the transfer of knowledge between people is by offering a series of gardening workshops on seed propagation, composting methods, and site selection. By providing assistance in growing vegetables and fruits, these workshops provide information on how to minimize an individual's carbon footprint. In addition, a large amount of produce that comes out of the garden is either distributed at community events or sold at the local food cooperative, thereby helping to communicate the joy and simplicity of growing food in Canberra and thus reducing emissions generated in food transport.

Sustainability Internship Program

The Sustainability Learning Community facilitates workshops and internship programs aimed at providing students with skills to promote sustainability on campus, in the workplace, and in their future careers. Each semester ANUgreen defines six to eight projects of current corporate interest and offers these to students through a competitive selection process. Students from all disciplines are encouraged to apply for this paid work experience opportunity. In 2008, 14 internship projects were completed on topics ranging from the investigation of standby power in the halls and colleges, data analysis of campus energy and water savings, the creation of an online sustainability pledge, a feasibility study of an ANU "park and ride" bus service, and a collection of green office case studies.

Since 2007, ANU has also been participating in an international sustainability exchange programme with partner institutions from the International Alliance of Research Universities (IARU). Three ANU students are competitively selected to spend six weeks overseas at the sustainability office of the partner university and three students spend six weeks working with the ANUgreen office. Students at each location live in campus accommodation and work closely with professionals at each of the universities to support the development and implementation of campus sustainability projects. These student projects are highly valuable to ANUgreen as they assist with implementing environmental programs and create a pathway for sharing information amongst higher education institutions. Students participating in internship programs gain real work experience which is vital in seeking future employment. Furthermore, their efforts allow them to see tangible impacts in the campus community which enable them to fully immerse themselves in the local relevance of climate change issues.

Academic Collaboration

Another successful collaboration, providing students with practical problem-solving skills and a connection to their campus, is the relationship between ANUgreen and academic coursework. Two later year ANU courses (Greenhouse Science in the College of Science and Corporate Sustainability in the College of Business and Economics) exemplify a linkage between curriculum and campus operations.

Students in these courses are involved in a range of practically based carbon emissions and mitigation projects including analysis of:

- The carbon footprint of an ANU student
- Greenhouse gas emissions produced through travel to campus
- The benefits of on-site organic recycling
- Offsetting air travel and car fleet emissions
- Green purchasing policies

After being given preliminary data, students research their topic with the understanding that it will contribute to the work of the sustainability office. Students produce reports and present their results to relevant staff who then review their findings for accuracy and possibility of implementation. Student research projects are invaluable in their assistance to the sustainability office as each of these topics have been identified as ANUgreen priorities. The academics involved in such assignments have responded enthusiastically as the applied projects meet key learning goals, reduce planning time, and generate student enthusiasm. Students work with the intent that their findings could lead to actual implementation in policy and procedure within the university and this results in increased enthusiasm and a sense that their work is both relevant and appreciated.

The success of such initiatives relies on collaboration between facilities managers and academics and recognition that both groups provide unique expertise in relation to sustainability. Furthermore, the success of this approach lies in acknowledging that given the opportunity and trust in their abilities, students are highly capable of not only participating in, but advancing campus greening initiatives.

Annual Sustainability Events

The Sustainability Learning Community provides informal opportunities for students to volunteer and participate in sustainability events. Each year on campus, a number of events are held with a positive sustainability message and student volunteers actively assist with coordinating the events and helping to promote environmentally responsible behaviours. The huge increase in student volunteers seen each year highlights the success of ANUgreen and the SLC in communicating a fun and positive sustainability message. Events such as Celebrate Sustainability Day and Earth Hour help to promote the festive atmosphere which encourages engagement and participation in sustainability activities.

Celebrate Sustainability Day is organized to demonstrate the vast array of sustainability initiatives operating on campus and in the local community. Approximately 20 market-style stalls were present in 2008 with activities including a clothing swap, mural painting, and the chance to drive an ANU electric buggy. Information stalls included the local Food Cooperative, ANUgreen, student residential green groups, local public transport providers, and the ANU Centre for Sustainable Energy Systems. Over 500 people attended the event and statistics were collected through the use of a passport system. Participation in an activity or a visit to a stall earns a stamp and prizes were given for those with the most stamps (first prize being a year's supply of green energy). This tactic promotes engagement with the event and provides a means of measuring interest and attendance.

ANU celebrates Earth Hour with an outdoor evening event aimed at demonstrating the link between climate change and personal energy consumption. In 2008, around 700 people attended the event which included an evening of acoustic world music and drumming along with the great switch-off of campus lights. Over 30 student volunteers and another 30 support staff were involved, including the Vice Chancellor. Averaging four hours of volunteer work each, these student efforts clearly demonstrate that the Sustainability Learning Community is succeeding in communicating and engaging students. Like Celebrate Sustainability Day, this success can be at least partially attributed to the way in which events promote a sense of community and celebrate the university's commitment to climate action.

The Sustainability Learning Community is highly successful in engaging *People* in campus environmental management by increasing awareness, fostering engagement, and celebrating environmental management successes. Students are an integral part of the campus community, and their involvement in campus operations provides many benefits such as helping ANU to improve its environmental performance, providing feedback and critiques of sustainability initiatives and thinking up new and innovative ideas, all of which enhance the university's "green" reputation.

The value of such student engagement is supported by the literature which highlights the importance of integrating academic and practical experiences. The university is a microcosm of the societal macrocosm and by working with students to create a sustainable campus, universities in turn promote cultural change and support students as change agents and champions of sustainability, both on campus and in their future employment (Rowe 2002; Pittman 2004). Calhoun and Cortese (2005, p. 7) summarize the significant potential of higher education institutions in both demonstrating sustainable practices and promoting stewardship values, saying:

> The educational experience of students is a function of what they are taught, how they are taught, and to some extent by the way in which the university manages, conducts research, operates, purchases, designs facilities, invests, and interacts with local communities . . . All parts of the university are critical in helping to create transformative change in the individual and collective mindset. Everything that happens at a university and every impact, positive or negative, of university activities, shapes the knowledge, skills, and values of students.

Involvement in campus sustainability initiatives helps students not only to recognize that they are a part of an institution with an ecological impact, but that their individual choices and actions do make a difference.

The Sustainability Learning Community, with its focus on linking theory to practice, aims to help students gain a sense of connectedness to the campus and to develop skills to engage with the environmental impacts that they encounter there. As shown in the case study above, the Sustainability Learning Community is an extremely successful method of communicating the issues surrounding climate change and the relevance these have for ANU by effectively using the campus as a classroom. All of these opportunities give students the chance to engage more deeply with the ANU as a place and as an institution with an environmental footprint. Although staff can participate and play a key role in the Sustainability Learning Community, the primary form of engagement with staff at ANU is through the SEE Sustainability at Work programme.

SEE Sustainability at Work

The Social, Environmental, and Economic Sustainability at Work, or SEE S@W Program, has been operating at ANU since 2004. In 2009 its membership included 155 staff across 33 campus workplaces. The SEE S@W programme consists of a series of workshops and resources aimed at helping staff to gather the skills necessary to promote sustainable behaviours in the workplace. The topics covered by the workshops include: *Creating Green Office Culture, Facilitation and Communication, Environmental Assessment and Reporting, Green Labs Development,* and *Action Planning, Implementation and Evaluation.* As well as having access to workshops, online auditing tools and ANUgreen expertise, staff Green Reps are each provided with a comprehensive sustainability resource kit. Each kit contains information sheets, posters, stickers and commitment cards on key areas of environmental management with information about improving environmental performance.

In late 2008, the opportunity to participate in the SEE S@W programme was made available to undergraduate students as a result of interest from the student community to participate in this process of cultural transformation. As staff are typically time-poor, the opportunity to gain real-life experience and practical skills on the SEES@W program's workplace sustainability auditing project is particularly appealing to students. Building audits help to provide a benchmark for improvements in workplace performance and students assist with approximately 20 different campus workplace audits annually which serve to identify opportunities for improving performance, reducing operational costs and tracking progress.

A key engagement initiative for ANU staff is the 10% by 2010 programme. The programme aims to achieve a 10% reduction in energy usage on campus by 2010 (from 2006 levels). One of the strategies to do so involves encouraging staff and students to publicly commit to an environmental action or behaviour for a three month period. This commitment can take the form of an online pledge or a signature on a postcard which is then displayed on the desk. At the end of the three month period, those who participated in the online pledge are asked to log in and leave feedback on the experience of upholding their commitment, and those with postcards are asked to return them with a witness's signature. All participants then go into a draw to win prizes which range from coffee vouchers to a roof-top solar energy system, all of which are donated by local businesses. Through this commitment programme individuals can reflect on their ecological footprint while on campus and local businesses can promote green products. Posters designed by student interns are displayed across campus to help promote the competition, representing yet another way the campus can act as a classroom for climate change awareness and action.

In the first three months of the 10% by 2010 programme over 500 commitment cards were distributed. Many staff members stated that they were reluctant to return the cards to go into the prize draw as they provided a daily reminder to take environmentally positive action. 10% by 2010 has proven to be a successful communication tool for ensuring that staff and postgraduate students become aware of the impact of their behaviour as well as providing a pathway to changing behaviour. The commitment cards and associated promotional materials also serve to communicate the value of collective effort.

The SEE S@W programme offers professional development opportunities for staff and successfully assists them to encourage their colleagues to participate in improving the environmental performance of campus departments. The ANUgreen programme also seeks to support staff by providing infrastructure and services that promote sustainable behaviours. The Timely Tredlies Departmental Bicycle Fleet is an excellent example of providing resources that encourage people to make transport choices with sustainability in mind.

Timely Tredlies Bicycle Fleet

The Timely Tredlies departmental bike fleet was introduced to the ANU campus in 2006. Since the initial launch of 20 bicycles, the programme has grown to become one of the largest corporate fleets in Australia with a total of 70 bicycles. In addition, a programme for secure bicycle storage has provided 500 spaces to date, with a further 500 planned. These facilities should encourage staff and students to commute to campus with their own bicycles, further reducing vehicle use both on and off campus.

The ANU campus covers a large tract of land and is located 1.5 km from the Canberra CBD, therefore University fleet vehicles are often used for transport over short distances. The introduction of the bicycle fleet has helped to facilitate the use of active transport methods and to reduce motor vehicle use. The distinctive red bicycles and lime green logo provide an effective advertisement for the programme.

The Timely Tredlies are centrally managed by ANUgreen. Departments express an interest in receiving a bicycle and, in exchange, must provide a local area coordinator and a safe and secure location for bicycle storage. Bicycles are provided with helmets, locks, lights, panniers, trouser clips, puncture repair kits and cycle computers and these are lent out to staff through the same booking system as fleet vehicles. The bicycles are collected annually for service and this allows the Sustainable Transport Officer to record kilometres travelled and gather feedback on the programme. Feedback suggests that the Timely Tredlies programme is a fantastic "vehicle" for communicating the ease with which the campus community can embrace sustainable transport. Comments from local users include:

> The bike has been the best addition ... we are seeing it used for short journeys across campus and for trips to the city normally taken by taxi.
>
> The Timely Tredlies programme has been the saving factor in our IT specialist's daily routine. He is committed to several Centres on campus each day and rides from here to there and back once or twice daily – that takes care of the red bicycle. Before we registered with the programme he walked – very time-consuming.

The programme has reduced the number of cars being used around the campus along with the carbon emissions associated with those vehicles (a 12.5% reduction in fleet vehicle emissions was seen in 2008), thereby improving the quality of the campus environment. The presence of the bicycles themselves has also served to create a social and physical environment which suggests to the campus community that the University takes environmental education seriously. The Timely Tredlies are a prime example of how word of mouth becomes a powerful communication tool in educating the campus community about sustainability. As they are visible, recognizable and functional, the bicycles send a clear message. The Timely Tredlies have also attracted significant media attention in the form of radio interviews, newspaper articles and campus media, while numerous presentations have been delivered to local and national organisations. The Timely Tredlies programme helps to ensure that the university is known for its commitment to *People* (by providing functional alternatives to the car), *Place* (by recognizing the importance of the campus landscape and reducing car presence) and *Performance* (by reducing overall greenhouse emissions).

Place

A university campus is often seen to have two distinct environments, a built environment, comprising buildings and landscapes, and a learning environment, made up of academic departments, classrooms, students and faculty (Rohwedder 2004). As the structure of the educational institution impacts the way in which students see the world and act within it, the physical campus should be recognized as a tool for teaching sustainability. In the ANU Environmental Management Plan, *Place* refers to the physical components of the campus including the landscape and built environment. Through this physical landscape, ANU seeks to send the message to all staff, students and community members who step onto campus, that sustainable practice is at the heart of university operations and policy. This is communicated through the development of physical infrastructure as well as through the campus landscape and its use as an educational resource. As well as reducing campus environmental impacts, the intention is to establish community values that translate into organizational values which will offer continued support for sustainability initiatives. The goals of *Place* are to use the physical features of the ANU to conserve energy and water, reduce waste, educate the community and achieve other sustainability goals. In this section, these goals will be analysed using the example of the Green Loan Fund for financing sustainability infrastructure and the Urban Biodiversity Program.

Green Loan Fund

The campus is home to a large number of buildings of various ages and environmental credentials, providing an excellent opportunity for demonstrating the available options for retrofitting existing buildings and for developing new ones in a sustainable manner. In the past, most initiatives were considered on the basis of a return on capital investment within three years, thus sending a clear message – financial savings are the priority and environmental outcomes are a bonus. The introduction of the ANU Green Loan Fund in 2007 sent a strong message to the campus community that the university is committed to improving its environmental performance by means of infrastructural upgrades. This three million dollar fund was established by the Vice Chancellor to provide interest-free loans to departments for projects that will reduce their environmental impact in critical areas like water consumption, greenhouse gas emissions and waste management. Units are able to apply for funding, between A$20,000 and A$250,000, for projects that demonstrate environmental benefits and have a payback period of less than ten years. The payback period is determined by calculating the length of time it will take for the implemented technology to pay for itself. As the loan is interest free and long term, business units are able to install technologies with longer payback periods without struggling to meet initial capital costs. In turn, this encourages business units across the university to look for innovative technological ways to reduce energy and water consumption.

A Green Loan Fund project at the Research School of Chemistry will allow for the purchase of a Helium Gas Recovery and Reliquefaction Process Unit. This unit will enable the school to reclaim at least 80% of the 8,000 L of liquid helium used each year for cooling magnets in the Nuclear Magnetic Resonance Spectrometer. As the helium is currently sourced from Russia and is a finite resource, the implementation of this project will reduce the environmental footprint of the university. Installation of technology such as this communicates the need for understanding and appreciation of the impact of research on resource consumption.

The campus residence, Bruce Hall, was also a recipient of the fund, enabling it to install dual flush toilets. Although not a dramatic infrastructural improvement, water savings of over 24% have been reported within the first year of installation and it is expected that the loan will be repaid within four years. Signage in the Hall promotes this achievement to student residents and suggests that they, too, can play a significant role in saving water.

The Green Loan Fund has been highly successful as it demonstrates a financial commitment to sustainability from upper levels of university management. These measures help staff to feel supported by an institution that is striving for a sustainable campus.

Urban Biodiversity

The natural amenity of the ANU campus offers a wonderful resource for teaching the lessons of sustainability. It is intended that the physical and natural environments will promote learning for sustainability by demonstrating how they can work together in addressing sustainability concerns as diverse as energy and water consumption and maintenance of green space. For example, a sheltered outdoor learning space is being planned which will provide space for tutorials, small lectures, and study groups to work in an outdoor space, using natural lighting, heating, and cooling. This space will be situated in an existing landscape exhibiting high water consumption and will be specially designed to minimise the need for artificial irrigation. The development of such "learnscapes" (Tyas Tungaal 1999; Skamp and Bergmann 2001; Cross 2006) provides opportunities to reconnect students with the landscape while also contributing to operational efficiencies through reduced energy and water consumption. This will provide a teaching space where the campus literally acts as a classroom.

Biodiversity is an important aspect of campus environmental management but communicating its importance in relation to climate change can be difficult. The ANU has addressed this through a number of approaches including a sub-catchment ecological survey and the development of a Biodiversity Management Plan (BMP) to inform sustainable landscape design. The most powerful early successes in communicating climate change and the value of biodiversity have been through the development of distinct sustainable landscapes. These landscapes, targeting species diversity and flood mitigation, have provided valuable stepping stones in educating the campus community and facility managers about the value of incorporating biodiversity in landscape design.

In 2004, ANUgreen initiated a collaborative project with the Australian Phenomics Facility Building Contractors to incorporate ecological values into the landscape surrounding the facility. In consultation with a frog specialist and ANU gardens and grounds staff, a landscape feature was designed to allow water to slowly infiltrate into the soil, creating a seasonal water body. The design incorporated habitat features, including hollow logs, rocks and native flora to provide a year-round habitat for small reptiles, frogs, and invertebrates. Near the end of construction, a Whistling Tree Frog (*Litoria verreauxii verreauxii*) was sighted in the landscape. This frog had not been recorded on ANU grounds previously. Recordings of the species in the adjacent Australian National Botanic Gardens would suggest that the frog dispersed to the site from the gardens and that the development of habitat was successful in encouraging wildlife to the site. Outdoor signage has been erected to promote this success and to communicate the value of linking landscape to performance.

Building on the success of the frog habitat, ANUgreen began to collaborate with adjacent landholders to address a joint weed management issue along a drainage line extending from a nature reserve through to Sullivans Creek on campus. The resulting landscape has seen the removal of weeds of national significance to provide an improved aesthetic vista to a main campus entry. The landscape utilizes no artificial irrigation to maintain plantings, is designed to contribute to on-site drainage of water and has the potential to provide future habitat as the landscape becomes established.

The ability of the ANU to report on the value of the landscape and climate change as it directly relates to the ANU campus relies on conducting cyclical frog, bird, insect, and mammal surveys. These surveys provide information on changes in faunal distribution and allow the university to gauge the success of landscape intervention, while also playing an important role in generating interest in the campus itself. Staff and students along with local community experts participate in the surveys. Learning through participation and involvement is typically more successful in communicating the message of sustainability than learning in the classroom alone. Experiential learning also provides the additional benefit of engaging the campus community and other volunteers in a social context. Through this mechanism, information can be communicated on the value of biodiversity and the campus landscape in managing climate change. Networks are also established as positive ways of enabling information exchange with the wider community.

The importance of preserving the environment for biodiversity outcomes is a key component of communicating for climate change on the ANU campus. The Urban Biodiversity Program provides a good example of using the natural environmental as a *Place* for communicating climate change.

Performance

The role of *Performance* in the Environmental Management Plan is to guide the actions of each individual in the campus community in order to achieve world's best practice in resource efficiency and waste minimization.

One of the challenges facing many organizations is determining how to improve performance through more efficient resource consumption and then to communicate the effectiveness of any measures implemented. While the previous case studies have shown the value of engaging with the social and physical environments of a university (for both increasing awareness of sustainability issues as well as improving performance), simple and measurable performance outcomes can themselves be valuable tools for communicating a sustainability message. A wide range of recycling programs have been implemented at ANU including paper and cardboard, plastic and glass, steel, batteries, fluorescent tubes, toner cartridges, mobile phones, Styrofoam, office furniture, demolition and construction waste, organic matter and IT waste. While many of these examples, as well as others relating to energy and water consumption, have positive performance outcomes, the examples discussed below have been chosen for their innovative and appealing approaches and simple performance measures. In this section the ANUgreen Organic Recycling Program and the Furniture Redistribution Program will be explored for their contribution to resource efficiency and waste minimization.

ANUgreen HotRot Organics Recycling Project

Organic matter, including food scraps, makes up one-third of the waste stream on campus. When sent to landfill, food waste, or putrescibles, is classified as hazardous waste as it produces pathogens and toxic liquids known as leachate. The ANU HotRot Organic Recycling Project is the only large-scale putrescible waste diversion project in the region and only one of two operational HotRot units in Australia. The HotRot in-vessel composting unit takes organic waste from around the campus and turns it into compost in just three weeks. This technology can divert 500 tonnes of organic waste from landfill per year. The ANU already has a well-established green (garden) waste composting process and the combination of these two composting systems ensures production of a compost rich in nutrients. Once produced, this compost is then returned to campus landscapes including the Sustainability Learning Community organic garden.

With the capacity to divert up to one-third of the campus's entire waste stream there is huge potential for this project to greatly reduce the university's emissions. The success of this programme is communicated through online resources, staff seminars, cleaning contracts and the provision of specific and clearly labelled 120 l and 240 l wheelie bins to halls of residence, restaurants and cafés, and other university departments. Food waste and other organic material is placed in these bins by the users (kitchen staff, chefs, students and staff) which are then collected by ANUgreen for composting. Food waste is now viewed as a valuable resource, rather than a waste stream, an excellent *Performance* outcome.

The organic recycling programme has been so successful in its communication that a large number of people have requested information, tours, and presentations. Performance outcomes of the technology and its uniqueness in the Canberra region mean that other organizations looking to improve their environmental credibility regularly request assistance. Recently the programme was able to assist two community-based fishing events where pest species of fish (carp) are removed from Lake Burley Griffin, adjacent to the campus. Over 1.9 tonnes of fish from these events were effectively composted. Similarly, 1.2 tonnes of food waste was collected and composted from the four-day National Folk Festival. By helping to improve the performance of these community events, ANUgreen communicates to the campus and local community its commitment to climate change action.

Further extending the value of the HotRot Organic Recycling Program in communicating climate change has been the involvement of both undergraduate and postgraduate students. As part of their coursework, students have analysed the carbon emissions avoided by diverting this waste stream from landfill. In research, both students and academics are looking at the microbial communities in the compost to enhance understanding of the composting process and to improve the process itself. While traditional academic research generally looks outside the university, this model of research is unique because the focus is geared internally on the institutions' own functioning which will ultimately lead to an improvement in environmental performance and reputation. This convergence of education, research, and operations around the composting project also demonstrates an important link between the everyday practice of food consumption and actions that both the individual and the institution can take to achieve positive performance outcomes.

Furniture Redistribution

ANU has a comprehensive recycling system in place designed to reduce waste to landfill and to ensure the re-use of materials wherever possible. The redistribution and recycling of campus furniture has been a particularly successful component of the Waste and Recycling section of the Environmental Management Plan. Since 2004, ANUgreen has been facilitating the collection and redistribution of office furniture across campus. Unwanted furniture is collected from business units and if the furniture is in good condition, it is stored on campus to await a new home and if it is no longer functional, the components are sent to be recycled. Staff looking for furniture can contact ANUgreen to locate second-hand items.

Significant financial savings have been realised from this programme and are used to justify funding a coordinator who organizes furniture pickups and distribution. In a two-year period (2006–2007) 1,125 items of furniture were collected and reused or stored for future use by ANU departments. This represents a significant decline in waste to landfill and reduced emissions given reduced demand for the production and transport of new furniture. The effectiveness of the programme is demonstrated by the increasing number of calls fielded by the ANUgreen office regarding the programme. The programme offers a convenient service to the ANU community and helps to relieve the financial burden of new furniture. Only advertised through word of mouth, the performance of this programme is the key to its success.

A focus on *Performance* is an important and necessary part of any programme aiming to reduce an organization's carbon footprint. Strong performance outcomes in areas that are easily communicated and appealing to the community are vital for ensuring the success of any Environmental Management Plan. In the cases outlined above, the real success has come from the ability of the university to work with people on the campus to develop, promote, and implement initiatives that yield improved environmental performance. Both the HotRot Organic Recycling Project and the Furniture Redistribution Program have successfully connected with people because of their visible systems and tangible outcomes. Performance success is seen on campus not only in statistical results, but in actively communicating the value of closed loop systems for environmental and economic outcomes.

Conclusion

The ANU campus provides an extensive space, both within and beyond the classroom, for educating staff and students about climate change and related environmental issues.

The ANU Environmental Management Plan is the key document guiding the university's integration of sustainability principles into campus operations. The EMP is organized around three concepts which highlight the importance of effective community engagement (*People*) in achieving sustainability goals for the natural and built environment (*Place*) and for efficient resource use (*Performance*). Such an approach recognizes that a university operates with the complexity of a mini-city and in order to operate and educate in a sustainable manner, all of its interdependent parts must be considered. By implementing the *People*, *Place*, and *Performance* framework, ANU has developed a holistic strategy for utilizing the entire campus as a classroom for teaching and communicating the principles of sustainability.

Utilizing the campus as a classroom is an important part of promoting environmental literacy amongst both staff and students. Sustainability is best taught not as a "grand abstraction" or as an isolated management problem needing to be solved, but as a tangible concept relating to the places where we live our everyday lives (DeLind and Link, 2004). Hence, the campus community is an ideal place for staff and students to both learn strategies for instigating change and to gain a framework for appreciation of global issues by developing knowledge of local issues.

The learning experience of students is influenced by more than what is taught in the classroom. Universities educate not only via the "manifest" or explicit curriculum of the classroom, but also via a "latent" or "shadow" curriculum representing the university's principles in administration and management of campus operations (Bloom 1981; Rowe 2002). This shadow curriculum represents an excellent opportunity to authentically teach the concepts of sustainability; the learning process will always be enhanced when the daily practices of an institution reinforce the lessons taught in the formal curriculum and vice versa. While core functions such as management and operations have traditionally been viewed as providing only logistical support to the academic mission of the institution, a powerful learning experience can emerge from beyond the classroom when students are engaged in the operational aspects of the university.

Student engagement in sustainability initiatives raises the profile of the projects and in turn helps to raise awareness of campus sustainability amongst the broader student and academic population. By working with students to foster a more sustainable campus, the university also promotes environmentally responsible citizenship by empowering students to become agents of change. Orr (1992) stresses the importance of creating learning environments where students can develop meaningful relationships with their immediate environment, as well as the skills to design and implement solutions to the problems they may encounter there. He describes the experience of finding workable solutions to campus issues as "an antidote to the despair felt by students when they understand problems but are powerless to effect change" (Orr 1993, p. 5). By involving students in campus activities and practical sustainability research, students gain a sense of ownership and connection to the campus. Participating in campus-based projects makes students realise that they are stakeholders, along with faculty and staff, in making the campus a sustainable environment. Ultimately it is hoped that students recognise that they are environmental stakeholders wherever they choose to live and work (Clugston and Calder 1999).

The ANU Sustainability Learning Community is an initiative that offers students the opportunity to become involved in sustainability projects on campus, gain practical competence and see their ideas implemented in real-life situations. The SEE Sustainability at Work programme offers similar benefits to staff by providing a practical framework within which to engage with and promote campus sustainability. A successful programme must establish an obvious correlation between the individual's behaviour and the environmental impact of the institution. To achieve this change it is necessary to draw upon the personal values that lead to changes in behaviour while at the same time addressing infrastructural issues that obstruct sustainable behaviour. The Timely Tredlies Program is an example of the way in which a programme aimed at influencing the behaviour of individuals relies heavily on available infrastructure and services.

If the key to establishing behavioural change is to address the disjunction that often exists between an individual's intent to act sustainably and their capacity to fulfil that intention, a university must ensure that the physical infrastructure of the campus allows the individual to act appropriately upon their intention. For example, sustainable behaviour can be facilitated by installing small compost bins in every office or kitchen area, by providing incentives to use public transport and by signposting the reasons behind decisions in the landscape. Visual cues can also serve to reinforce sustainability as a corporate value. For example, an institution could place recycling stations on major pedestrian traffic routes, implement campus bike programs, install Process Cooling Units in laboratories and feature landscapes that highlight biodiversity and/or encourage the community to meet or teach outside. Such actions clearly acknowledge the lessons offered by campus management and operations, or the "shadow" curriculum. Campus infrastructure therefore can both assist an individual to behave more sustainably and by its very presence, communicate the concepts of sustainability to all members of the campus community.

All of the initiatives discussed in this chapter are successful because they recognize the value of considering *People*, *Place* and *Performance* in their operations. Campus sustainability initiatives are a valuable tool for developing environmental literacy as they demonstrate effective climate action to staff, students, and the broader community, thereby building awareness and encouraging environmentally responsible behaviour. Using the campus as a classroom is an effective and engaging way of integrating *People*, *Place* and *Performance* in communicating for climate change.

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Chapter 11
How to Educate for a Healthy Climate at a University? An Intergenerational Cooperation (A Case Study from Slovakia)

Alexander Fehér, Martin Hauptvogl, Petra Trangošová, and Lucia Svetlanská

Abstract This chapter will give an overview of teachers' and students' experience in learning about climate change issues at the Department of Sustainable Development, Faculty of European Studies and Development of the Slovak University of Agriculture in Nitra, including good and bad practices. It has been written by a teacher and three students with the purpose of integrating different views and approaches. The curricula and study methods of the Faculty of European Studies and Regional Development have been analysed from the point of view of education about climate change. The authors state that knowledge transfer must be followed by motivation for action. It can be said that much has been done to achieve more effective education at university; however, more effort has to be made mainly as regards removing formalism. The "why", "what", and "how" seem to be inseparable.

Keywords Climate change · Education for sustainable development · Intergenerational cooperation · Study methods

Introduction

This chapter has been written by four authors of different ages, who represent different participants of the educational process (one student of bachelor studies, one student of master studies, one PhD student and one university teacher) in order to provide a comprehensive and intergenerational view on the university teaching under analysis. The Department of Sustainable Development of the Faculty of European Studies and Regional Development at the Slovak University of Agriculture in Nitra, Slovakia, takes part in the education of students of the study programmes in the European Development Programmes, Regional Development, Management of Development of Rural Landscape and Rural Tourism and also in Environmental Management. This education is focused on sustainability issues

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including social, economic, environmental, institutional, political and other relevant aspects of society development. One of its priorities is to integrate different aspects and approaches into a complex, holistic view with high inter-disciplinarity. Climate change is being taught as an important issue in courses such as Sustainable Development or Natural Resources. The global changes are also discussed in international courses within the activities of the Baltic University Programme coordinated by the Centre at the Uppsala University in Sweden, mainly in the courses of Sustainable Baltic Region and Environmental Science. Apart from direct study methods (lectures, seminars), new didactic methods are used as well, such as team work, written semester projects, participation in student conferences, professional excursions etc. Let us start with the students' view and needs.

To be Educated (the master students' viewpoint)

Handling the problem of climate change is one of the biggest challenges faced by everyone. The territory of Slovakia belongs to the mild climatic zone. The climate is characterized by a great variety of climatic conditions resulting from changing latitude, elevation differences and partial differences in continentality as well.

The first step in recognizing the importance of climate change in our lives is to imagine its influence on human beings. The process of climate change is considered to be one of the most discussed problems among scientists, experts and teachers all around the world. Ecosystem degradation, global poverty and climate destruction are caused by a very close connection with human activities. People are altering the environment in catastrophic and irreversible ways. That is the reason why the system of modern education is so important in climate change processes. It can be stated that every complication to sustainable development is the output of human beings; therefore, only humans are able to make up for their losses.

Education at all levels, from pre-school to university, plays an important role in the case of sustainable development and climate change. It is clear that it is a tool that develops public awareness and the understanding of global problems and, what is more, it is a tool that can help to contribute to a better and sustainable future. Our young generation represents fresh opinions that need to be implemented into practice. However, the new understanding, approach and ideas have not been given sufficient space in the processes of global climate policy.

Students in the Slovak Republic are able to recognize and explain how much still needs to be done within their country's current educational system. There is a lack of modern technology in this area. It needs efficient mechanisms, sufficient funds, and knowledge in order to adapt to unavoidable climate changes. From the point of view of students, it is very important to create the best conditions for them. Universities, together with teachers, who should have no problems with having access to continuous education and training on issues connected with sustainable development and climate change, should be able to provide them, as future decision makers, with the best tools and knowledge. It is necessary to realize that students especially fall under the generation of people who need to be aware of global problems so that they will know how to act in a responsible way. Moreover, if they have good knowledge, it will be easier for them to find the solutions to the problems in the near future. There is a wide range of negative aspects which must be eliminated by humans. The students, as an upcoming generation, should help to inform people about the seriousness of climate change and to face problems by reducing emissions based on equity principles. We need to minimize the global concentration of greenhouse gases (at a level below 350 ppm) and strengthen the power of global institutions and their capacity to handle challenges in the area of sustainable development effectively. It is crucial to acknowledge the fact that the central role of the ecosystem lies in sustaining life on this planet as well as upkeeping the climate system. The fundamental duty of people is to respect the unique and irreplaceable place of other species on the Earth.

The main problem we can observe in our system of education is the lack of practice, the lack of funds and the inflexibility of administration structure which makes everything very difficult. Recognizing that we need a transformation of our educational system, we have prepared questionnaires on teaching about sustainable development. The aim of these questionnaires has been to find out the ways to change the contents, form and organization of education at our universities in a positive way. According to the questionnaires, the interdisciplinary approach is very important with regard to education for sustainable development. The students should be provided with up-to-date knowledge on sustainability issues, so that they have a deeper understanding of global problems. They recommend greater comprehension of issues concerning sustainable development in the curriculum and they think that the creation of a web portal with up-to-date information and advertising brochures could be very useful. The students want to have the opportunity to be actively involved in solving problems such as climate change and express their own opinion, as well. Taking part in the process is the only way of gaining experience and avoiding the fact, which is typical for our universities, that the students usually have a good theoretical background, but lack practice. The next point of the respondents was learning by new innovative methods. From our research, we can see that role-plays, e-learning programmes, discussions and workshops are considered to be the most preferred and effective ways of learning. The students, no matter what level they are, simply like learning by having fun. This is the reason why special courses about sustainable development should be attractive for them in some way, so that they can become more interested in learning about this subject. It is clear that students think that international and national projects, programmes, conferences, seminars, publications and multimedia programmes are essential for educating people about sustainable development. Special focus should be put on international cooperation and the organization of international meetings, simply because they are often of particular value.

To sum up, on the basis of the questionnaires which have been filled in by the students of Slovak universities, these activities could contribute to changing our living habits and improving the quality of our lives. Based on the results of our research, we think that these examples for sustainable education could help us to escape the threat of climate change and move towards a sustainable future.

In a global framework, climate change is a human rights issue and it influences the basic right to life, water, and nature. Therefore, we have to realize that climate change really represents one of the greatest threats facing the planet and we should do something about it. It is high time to act in a responsible way. By this, we mean not damaging the planet and trying to improve the quality of life. There is still time to change people's wrong attitudes and time to participate in creating a better future. It may seem a pipe dream, that it is not possible to change people's minds these days, that it is simply too late. The students are realistic and know that it will not change everybody at once, but there is a chance that people will start to think about it and maybe some of them will see what is going on. However, to make more and more people aware of the situation, education about sustainable development is needed. In our opinion – the students' opinion – changing the educational system should be the first step towards sustainable development and climate change.

To Be More Educated (the PhD Students' Viewpoint)

Global change is a very difficult subject and nobody, not even the most prominent scientists, can say that they know everything about it and have the right solutions. However, we should be able to distinguish the correct information from the incorrect and learn to verify it. In this case we might be able to work with the best information and thus find the best possible solutions. This may be the main principle of education.

Climate change is a fact and humans have their own impact on it. We have significantly increased the concentration of carbon dioxide in the atmosphere and thus contributed to global warming. Another fact is that whatever we do, even if we stop the emissions today, the temperatures will continue to rise. Therefore, we must seek the best possible ways to mitigate our impact and to adapt to the changes that are occurring. There is scientific evidence that global temperatures are rising and their effect on the environment and mankind is getting stronger and will be significant at the end of this century. But is it really as disastrous as we hear and read almost every day in the media? What is the real truth about the state of our environment? Who is right? Is it the people who say we are going to pay a great price for our behaviour towards nature or the ones who say that we do not have to worry about the future climate because our impact on global warming is nothing in comparison with natural events and cycles?

The task and at the same time the big challenge of education, especially with regard to climate change, is to seek the true information and move forwards with it. So again, when we look at the facts we see that people contribute to global warming by emitting greenhouse gases, mainly carbon dioxide. This will cause the expected rise in temperature of 2.6 °C at the end of our century if we continue with the "business-as-usual" scenario, which means without any intervention. But what does this 2.6 °C mean? Will we be able to adapt or are we doomed, and will billions of people die? Are we able to slow down the temperature rise and if we are, what are the solutions? We need to collect the facts and work with them. We would like to stress that discussions on climate change should be brought to an interdisciplinary level. The environmentalists should talk together with economists. We have noticed that this kind of communication is missing. The discussions on global problems are usually one-sided oriented and we lack any kind of feedback from other sectors.

Being environmentalists, we have never really paid much attention to anything related to environmental issues which comes from economists or statisticians. We always saw them as people who only care about economic growth and do not care about our environment and therefore ignored their point of view. Our societies are based on economy and therefore we must cooperate with each other. We have learned that economics is about who gets what and why. In this sense, a clean environment is part of the economy. It seems that the most efficient way of dealing with many global problems are externality charges on waste, pollution or carbon dioxide emissions.

Our short experience with teaching has shown us that students of our university are not very willing to talk and discuss. They receive information from a teacher rather passively. If we investigate the reason for this, we might come up with several answers, but these would not solve the problem. Therefore, the question should be: what can we do about it? We think teachers should focus more on conversation with students. Make them talk and write as a main part of the evaluation of their participation in seminars. One possibility for such an approach could be the introduction of more practical "real life" tasks. If we try to involve students in solving practical problems, we will stir up their thinking. We must ask as many questions as possible and if there are no answers, or only a few, we should ask even more and try our best to encourage students to respond and also teach them to ask questions. Students should become accustomed to an educational approach based on discussions. There are many questions that can be asked on the climate change issue. We can hear and read about it almost every day. A huge amount of information comes from TV, newspapers, and radio stations. Scientists, journalists, and politicians – everybody speaks about global warming. We should always bear in mind that the media tend to focus on conflicts and alarming news and thus exaggerate facts.

It is very important to spread and share good examples in order to move forward and be more efficient in the educational system. It has been proved that students can develop much better skills when they are involved in the teaching process and they can often approach other students more easily than teachers. They are many existing student centres that can also serve as a good example for our university. We can see a very good example of such a student centre in Uppsala in Sweden. The centre called CEMUS was established at the beginning of the 90s. The main goal was to involve students in the teaching process. Students work here on a part-time basis as part of the Uppsala University staff. Their responsibilities in the selected courses are to prepare seminars, lead discussions, provide lecturers, etc. The communication among students is therefore much easier and they usually find such courses very interesting.

I would like to recommend the establishment of a student centre coordinated by students themselves. Students could share knowledge through a variety of workshops. Such centres could also be places that provide a number of seminars and lectures. The coordinator students would be responsible for communication and bringing in lecturers or scientists from various fields and also people from practice in order to obtain different points of view on the given issue. An approach such as this would help us to get a more objective picture not just about global warming but also about other global problems. The most important skill we could obtain would be an ability to sort out accurate information from the fictitious. Discussions and confrontations are very important in any educational process. This way, students learn to form and express their own thoughts and opinions, which can lead to many great ideas. Furthermore, even the process of thinking itself is of great importance and leads to active participation in talks.

Climate change can become a factor that could bring many people together in the search for a better and sustainable future. There are many people, especially among students, who are willing to be part of initiatives focused on global problems. Communication networks among universities in different countries could be a great source of shared knowledge. We could learn from each other what individuals, as well as societies, can do by means of successful case studies and the good examples of the sustainable approach in individual regions.

In our modern societies, information is a powerful tool. We are dependent on the media that bring us all sort of information ranging from the weather forecast to global problems. Everyday information affects our minds and decision-making. Therefore, it is highly essential that it is well-balanced. Sensational information sells newspapers and makes people sit in front of televisions. That is a well-known fact. *Education should prepare students to be able to recognize useful information that they need for their professional decision-making.*

We have to admit that we used to have (and maybe still have) a dilemma in recognizing the place where a slight adjustment of a piece of information can help people to become active and take positive steps in order to reach a positive effect, no matter whether we are talking about social or environmental issues. We used to think it was better to scare people by exaggerated "facts" so that they are much more willing to change their lifestyle habits, rather than if they are just told that things are not so "bad". We also could not understand why some countries like the USA are not able to recognize the need to sign the Kyoto Protocol and thus help to reduce global emissions of carbon dioxide. But are they really so evil, minding only their own economic prosperity without caring for the environment and future generations? Maybe there are some obstacles that we do not usually hear about. Here again, attention is drawn to what we mentioned before: balanced information. Incorrect information can do a lot of harm even if it has a good intention.

Let us have a look at the Kyoto Protocol more closely. What kind of information do we generally get from the media? How do we generally see it? We must assume that it is a good thing, because it is based on simple logic: if carbon dioxide causes global warming, we should reduce its emissions. It is easy to understand and makes perfect sense. But what does Kyoto bring us in practice? The answer does not bring such a nice picture as we might have expected. It surprises many of us, especially when we know how big a role this agreement plays in global public discussions. It is also considered to be one of the greatest factors of discord between the USA and the rest of the world. If the Kyoto Protocol is fulfilled, the global temperature will rise by 2.42 °C at the end of the century. This means a 0.18 °C difference in comparison with the expected 2.6 °C rise. When we look further, we find that the temperature rise will be postponed for five years. In other words, the same temperature that will be reached in 2095 without any reduction would be reached in 2100 if the Kyoto Protocol was fulfilled. So by sticking to Kyoto, we save five years in the whole century. Finally, we can ask what the costs of the agreement are and we find out that it would be 180 billion USD every year (Wigley 1998). We should bear in mind that there will still be floods, droughts, and hurricanes (just to name a few catastrophes) that will kill many people. The Kyoto Protocol will not solve these problems; it will only make a negligible slowdown in temperature rise in the long term and at great expense. Of course, our responsibility is to think about future generations, but we should not forget about the present generation mainly in developing countries. Millions of people die of starvation and diseases caused by the lack of drinking water and sanitation, AIDS, and many other things. Natural disasters like tsunamis, floods, and hurricanes cause other significant death tolls and they occur independently of temperature. Therefore, the right thing would be to spend the money more efficiently on protecting endangered areas, improving sanitation and medical care, and securing access to drinking water and so on. And most of all, in the sense of climate change it is important to spend more money on funding research into alternatives to fossil fuels, which, interestingly, has been in decline in the last few decades. Such an approach would result in much higher benefits and lower costs. Most of all, it would save many more lives.

The anthropogenic impact on global warming is a fact and we must change our current "course" based on fossil fuels, but a very important thing is to give people true information based on well-founded scientific research and not on apocalyptic visions. The myths that sea levels can rise by 6 m, the threat of an ice age in Europe by the end of the century and so on are good only for Hollywood movies or the sensationalist media. Education on global warming should bring open, rational discussions about the problem we face and also the best possible solutions we can use.

Finally: To Educate (the Teachers' Viewpoint)

The "final product" of sustainable development and related issues is harmony between our environment and long-term well-being. Sustainable development considers resources for life in a relevant quantity and quality including human impact on these resources. There is a lack of understanding of education on climate change at many universities (faculties, departments, teachers). We suppose *we do not need special teachers for climate change*, except for a few specializations that are not relevant for our faculty (physics, climatology etc.) *but this "new quality" should be incorporated in different courses/subjects.*

Climate change is not a problem of nature but more that of people. At practice-oriented universities, like the Slovak University of Agriculture, it is not enough to teach the principles of sustainable development but it is important to explain how to implement them into decision-making and activities. Other problems arise from the wholly mono-disciplinary focus of specialized universities, because sustainable development is multi-disciplinary (the integration of natural sciences and arts). Knowledge transfer is dominant and the social and ethical development of an individual is underestimated. *Let us begin education on climate change with education for values.* Value-oriented education is very important because climate change is more a question of our behaviour than that of technology (we create the technology). On the basis of our experiences and that of other authors, we intend to consider four cornerstones of education: democratic process, critical approach, cross-disciplinary cooperation and pedagogical methods (cf. Fehér 2006). The same is expected for education on climate change. Formal knowledge transfer is not enough but is the most common way of education on climate change. There are different approaches to and explanations for this process, and the teacher must give the student the chance to choose his/her own understanding of global changes with relevant responsibility. To give the student more efficient and applicable skills, high-quality knowledge must be transferred not only from natural sciences but also from social, economic, political and other sciences. We can start with formal teaching and continue with applications based on the students' comments or start with easy motivational games (role-play etc.) and go into scientific details step by step. Our faculty has adopted several new manuals for teachers of sustainability issues published in the Nordic countries (NCM 2003; MES 2004; Jutvik and Liepina n.d.; Rohweder and Virtanen 2008; Ottosson and Samuelsson 2009, etc.).

Many functioning processes are generated in a bottom-up way, but in the case of education on climate change, a top-down process can also be accepted, because many students come from secondary schools without useful basic knowledge about this issue. In our practice we try to combine top-down and bottom-up processes. The ideal would be a good combination and integration of both pathways. Education on climate change is focused on:

- Natural processes affecting the climate
- The impact of human beings on these processes
- Tools to mitigate man's influence
- Adaptation to the impacts of climate change

We need a follow-up system. The biggest problem is the formalism in education for sustainable development and environmental sciences in Slovakia. Fact-oriented teaching is important but cannot directly influence the behaviour of people (students) who are the target group of education. The move away from normative education towards pluralistic education has taken a long time, and it is still in process (ex verb in Visby). What we need to promote is interdisciplinarity, to be critical and to have more action (in cooperation if possible). It is important to focus on measurable facts in nature or in society such as:

- Temperature and precipitation
- The biological invasions of microorganisms, plants and animals
- The melting of glaciers, etc

These processes are easy to interpret and understand and students are able to discuss them without detailed knowledge of physics, climatology, or hydrology. To change behaviour we need value attitudes and knowledge from three areas: natural sciences (e.g. ecosystem services), economical sciences (e.g. lack of sources or poverty), and social sciences (e.g. human rights, solidarity). These topics are included in different courses (Table 1) but we can see that climate change is discussed mainly in natural sciences and it is only marginally present in economic and social sciences. There is a big imbalance to be resolved in the future.

Table 1 shows courses for students of Bachelors and Masters studies at the Faculty of European Studies and Regional Development that include formal or effective, marginal, or essential issues on climate changes. The courses are listed as compulsory (C) or elective (E) in the study programmes of students.

The most important meeting point of teachers and students is usually on a university course. It often happens that the lecturer gives only "obligatory" knowledge without acting on it or implementing it. At the Slovak University of Agriculture in Nitra the didactics used in teaching climate change are similar to education for sustainable development (cf. Fehér 2006). The best combination of didactics is to use both:

- Activation methods (motivation by a film, problem teaching, etc.) and
- Creative methods (case studies, role plays, etc.)

Studying the programme of Environmental Management, the final thesis work of the students has to contain a conflict of interests. It is very important to teach the students to consider different interests and methods, resolving them in the context of sustainable living. What we really need is fair decision-making which considers climate health. We would like to give you some good examples of well-developed courses.

Example: The Course of Natural Resources

This course is compulsory for all students of the faculty and elective for students from other faculties. Climate change is involved in almost all topics of the course:

- Mineral resources (e.g. gas emission from mining and processing of minerals)
- Water management (e.g. water balance and climate change)
- Soil (e.g. carbon sequestration)
- Air (e.g. air pollution and greenhouse gases in the atmosphere)

Table 1 Courses for students of Bachelors and Masters studies at the Faculty of European Studies and Regional Development

Course	Study programmes			
	European development programmes	Environmental management	Management of development of rural landscape and rural tourism	Regional development
Air Protection		E		
Biological Safety		E		E
Biosociology (Conservation Biology)		C	E	E
Climatology		C		
Ecological Disasters		C		
Ecological Engineering		C		
Ecological Monitoring		C	E	
Ecology (Principles of Ecology)		C	C	E
Ecology in Water Management			E	
Economical Geography	C			
Economics and Price Assessment of Natural Resources			C	
Economics of Environment and Natural Resources	E	C	C	C
Ecophilosophy		C	E	E
Ecosystem Restoration		C		
Environmental Chemistry		E		
Environmental Ecology		C		
Environmental Functions of Ecosystems		C		
Environmental Impact Assessment		C		
Environmental Law		C		
Environmental Management		C		
Environmental Management System		C		
Environmental Policy		C		
Environmental Science (international course within the Baltic University Programme)		E		
Hydrology		C		
Industrial and Environmental Toxicology		E		
Integrated Management of Natural Resources		C		
Landscape Ecology		C	C	
Management of Ecosystems in Slovakia		E		

(*continued*)

Table 1 (continued)

Course	Study programmes			
	European development programmes	Environmental management	Management of development of rural landscape and rural tourism	Regional development
Management of Invasive Plants		E		
Management of Natural Resources in Protected Areas		C		
Natural Resources	C	C	C	C
Non-Production Functions of Natural Resources			E	
Projects on Exploitation of Natural Resources		C		
Protection Against Natural Disasters		E	E	
Protection of Environment		C		
Renewable Energy Resources		E		
Standards and Permits for Environmental Management		C		
Sustainable Baltic Region (international course within the Baltic University Programme)		E		
Sustainable Development	C	C	E	E
Theory of Risks		E		
Waste Management		E	C	

- Biota (e.g. response of ecosystems on climate change)
- Energy resources (e.g. the influence of energy production on CO_2 balance)

Example: The Course of Sustainable Development

This is a cross-disciplinary course including environmental, economic, social, institutional, ethical, and technological issues:

- Sustainable industry and material flows (e.g. carbon cycle)
- Energy production (e.g. renewable resources)
- Sustainable agriculture (e.g. methane gas emissions)
- Mobility and transport (e.g. air pollution from fossil fuels)
- Environmental policy (e.g. international institutional tools)

Slovak literature is not rich in books written on climate change but some Internet sources are proposed for reading (e.g. Climate Code Red from Spratt and Sutton 2008). More interactive information can be received at international student conferences organized e.g. within the Baltic University Programme. The students of our faculty assisted in the preparation of the Students' Declaration on Climate Change (published by Andersson 2009).

Problems at Slovak universities originate also from the fact that teachers are not motivated enough to implement new study methods because of low wages and social rank in comparison with experts from other fields that employ graduates (businessmen etc.). A university should be a model organization exhibiting the best practices in protection of the atmosphere (emissions, waste management etc.) but the lack of willingness and finances does not allow that.

Conclusions: To Educate and to be Educated

A selection of ideas and recommendations – a possible consensus:

The main problem we can observe (in our system of education) is the lack of practice, the lack of funds and the inflexibility of administration structure which makes everything very difficult.

The first thing to do is to find out what the students' needs are and what they are expected to know about climate change for their professional career. After this step, the teacher must transfer the knowledge on global changes that can help the students with their decision-making in their future job. The way to do this is a question of didactics that should include activation and creative methods.

We do not need special teachers for climate change but this topic should be embedded in different curricula.

Let us start education on climate change with education for value orientation (responsibility!).

Give people true information based on well-founded scientific research and not on apocalyptic visions (holistic perspective including benefits of climate change).

Education should prepare students to be able to recognize useful information that they need for their professional decision-making.

At first sight it seems to be that there are many courses where climate change issues are discussed; however, the problem lies in the non-proportionality of knowledge dissemination among different sciences: the best developed are natural sciences; in economic and social sciences there is less information on climate change. There are big differences between study programmes as well.

The students, regardless of their level, simply like learning by having fun. Once again: do not forget that the key to effective education is harmony between students and teachers, which is threatened by formalism at many universities (knowledge is often given without activation!).

It will be a long road to resolve the remaining problems, but the first steps have already been taken.

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Chapter 12
Targeting a Low-Carbon University: A Greenhouse Gas Reduction Target for the Australian Technology Network of Universities

Chris Riedy and Jane Daly

Abstract The Australian Technology Network of Universities (the ATN) is an alliance of five Australian universities, from each Mainland State, that collaborate on issues and concerns of shared interest. In February 2009, the ATN committed to reduce its aggregate greenhouse gas emissions to 25% below 2007 levels by 2020. This ambitious target was the culmination of more than a year of technical analysis and political negotiations. The target is supported by a comprehensive emission reduction strategy that prioritizes energy-saving measures and adoption of low-carbon energy sources.

This paper outlines the technical and strategic analysis used to decide on the target. In addition, the paper draws out insights from the negotiations between the five universities. The circumstances of each university differed with respect to the greenhouse intensity of the local electricity supply, projected growth, and the extent of previous action to reduce greenhouse gas emissions. The negotiations sought an equitable approach to address these differences, building on the principle of contraction and convergence. The ATN approach is a possible model for other university partnerships. Further, the political and technical challenges that emerged provide insights into the challenges that other universities need to overcome in responding to climate change.

Keywords Greenhouse gas reduction targets · University collaboration · Lessons and challenges

Introduction

The Australian Technology Network of Universities (the ATN) is an alliance of five Australian universities: Curtin University of Technology, Queensland University of Technology, Royal Melbourne Institute of Technology, University of South

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Australia, and University of Technology, Sydney. All were granted university status in a short period between 1986 and 1992, growing out of former Institutes of Technology that were renamed or merged with other educational institutions. Recognizing their common history and shared technological focus, the universities established the ATN more than a decade ago to collaborate on issues and concerns of shared interest.

On 31 January 2008, the Vice Chancellors of the five universities signed the ATN Declaration of Commitment to Local, National and Global Sustainability (ATN 2008). This declaration established six sustainability principles for the ATN. At the same time, recognizing that climate change response is central to long-term sustainability, the Vice Chancellors established an Emission Reduction Working Group (ERWG) to undertake a collaborative review of organizational energy use and greenhouse gas (GHG) emissions. The objective was to announce energy efficiency and GHG reduction targets at the ATN Conference in February 2009. At the time, very few Australian universities had established GHG reduction targets and the ATN sought to demonstrate leadership in the university sector through this initiative.

The ERWG comprises facilities managers, sustainability research staff and environmental officers from each university. It is the work of the ERWG that is the focus of this paper.

Policy Context

The ATN commitment to develop GHG reduction targets came at a time of rapid change in the policy context for climate change response in Australia. John Howard's conservative government, which had largely avoided mandatory action on climate change, was replaced by Kevin Rudd's labour government at the November 2007 federal election. Public support for stronger climate change response was a prominent feature of this election and the newly elected Rudd labour government moved rapidly to:

- Ratify the Kyoto Protocol
- Establish a long-term target to reduce GHG emissions by 60% between 2000 and 2050
- Begin development of an emissions trading scheme and put in place energy and greenhouse reporting mechanisms to support the scheme
- Set a National Renewable Energy Target to source 20% of electricity from renewable sources by 2020

Some of these changes had the potential to impact on the university sector. The *National Greenhouse and Energy Reporting (NGER) Act* came into force on 29 September 2007. The Act required corporations and facilities whose GHG emissions exceeded specified thresholds to register and report on their energy use and GHG emissions. The first reporting year commenced on 1 July 2008. When the Act came into force, none of the ATN universities had comprehensive GHG inventories to allow them to assess their reporting obligations under the Act. This made the development of GHG inventories across the ATN a key driver for the ERWG.

The anticipated impact of the Rudd government's proposed emissions trading scheme, now known as the Carbon Pollution Reduction Scheme (CPRS), was also a key driver for the work of the ERWG. The government intends to set a national GHG reduction target for 2020 and to use the CPRS as a primary mechanism to ensure the target is met. The CPRS will put a price on GHG emissions, leading to increases in energy prices. The ATN sought to reduce its exposure to future energy price rises by implementing energy efficiency improvements across its campuses.

The Target-Setting Process

The ERWG began meeting in early 2008 and continued to meet on an irregular basis right through to the announcement of the targets in February 2009. Most meetings were held as telephone conference calls to avoid travelling large distances across Australia.

From the outset, the ERWG agreed that any commitment to emission reduction targets needed to be realistic, practical, and cost-effective. That is, the targets were to be based on rigorous analysis of what was actually feasible at each university and supported by a realistic emission reduction strategy. The authors were engaged by the ATN to provide some of this analysis and to coordinate and facilitate the target-setting process. This role included chairing meetings of the ERWG, providing consistent methods for data collection, and undertaking analysis to support decision-making.

GHG Inventories

As noted above, none of the universities had comprehensive GHG inventories at the time the NGER Act came into force. Most of the universities did report data on energy use and GHG emissions to the Tertiary Education Facilities Management Association (TEFMA) as part of its annual survey.[1] However, this data only covered GHG emissions from building-related energy use and there were apparent discrepancies in how each university calculated these emissions. The ERWG decided to develop comprehensive and consistent GHG inventories for each university so that all opportunities for emission reduction could be identified and

[1] TEFMA has reported benchmark data comparing cost and performance of Australian Universities and TAFEs since the early 1980s. The survey began including GHG emissions in 2007.

considered. The previous calendar year, 2007, was chosen as the baseline year for the GHG inventories.

The authors provided each university with guidance on preparation of GHG inventories and provided a spreadsheet template to ensure consistency. Each university appointed a staff member to act as inventory coordinator – typically the facilities manager or a dedicated sustainability manager. The spreadsheet template required the inventory coordinator to input data on energy use and other activities and emissions were calculated using emission factors provided by the Australian Government (Department of Climate Change 2008).

The initial intention was to include all Scope 1 and 2 emissions and selected Scope 3 emissions as defined in the Greenhouse Gas Protocol (WBCD & WRI 2004)[2]. However, underlying data availability varied across each university, making it difficult to select a set of Scope 3 emission sources that all universities could report on. Further, the NGER Act does not require reporting of Scope 3 emissions. The ERWG therefore decided to exclude Scope 3 emissions from the analysis, but to work towards consistent reporting of Scope 3 emissions in future years.

Total Scope 1 and 2 emissions during 2007 across the five universities were estimated at 241****kilotonnes CO_2-e, which corresponded to 16.8 tons per full-time equivalent staff member, 1.9 tons per student and 161 kg per square metre of gross floor area (GFA). None of the universities exceeded the corporate reporting thresholds in the NGER Act for the first reporting year but some had specific facilities that exceeded the thresholds and others expect to exceed the thresholds as they are lowered in future years. Interestingly, there was substantial variation in emission intensity across the universities. For example, the emission intensity of GFA ranged from 107 to 185 kg CO_2-e per m^2. This wide variation raised questions about how to take into account previous GHG reduction and the differing circumstances of each university. This issue is discussed in a later section.

Energy Audits

As part of the target-setting process, each university was expected to undertake a comprehensive energy audit to estimate the potential for energy savings. The universities commissioned energy audits separately but using a collaborative approach, where tender documents were shared between different universities. The energy audits differed substantially in their accuracy and timing. Some universities commissioned detailed energy audits to characterize energy and cost savings to ±10%, while others commissioned higher level reviews. Most

[2]The Greenhouse Gas Protocol defines Scope 1 emissions as direct emissions from sources that are owned or controlled by the organization (e.g. emissions from natural gas consumed on-site). Scope 2 emissions are indirect emissions resulting from electricity use. Scope 3 emissions are other indirect emissions, for example from waste disposal, wastewater treatment, or employee travel.

universities only had draft audit results available at the time when the targets were set and one university did not undertake an energy audit at all.

The data available at the time the targets were set identified potential GHG emission reductions of 7–21% across four of the universities from implementation of energy-saving measures. To realize these savings would require capital investment in the order of $7 million per university with a simple payback of 3–10 years.

Establishing Target Characteristics

When the ERWG began to meet, it was unclear what form the eventual target would take. The authors developed a discussion paper outlining options for target characteristics and the ERWG subsequently agreed to the target characteristics outlined in Table 1. These became the foundation for subsequent negotiations on the detail of the targets.

Table 1 Agreed characteristics for the ATN target

Agreed target characteristic	Rationale
The target will be relative to 2007 GHG emissions	This was the year of the first comprehensive GHG inventory across the five universities
The target will cover Scope 1 and 2 emissions	Some universities were not able to report on important Scope 3 emission sources (e.g. air travel) due to lack of suitable data The NGER Act only requires reporting of Scope 1 and 2 emissions
Target years and reporting will be on a financial year basis	Consistent with the requirements of the NGER Act. The Australian financial year runs from 1 July to 30 June.
Targets will be set for 2012–2013 and 2020–2021	The interim target (2012–2013) marks the end of the first Kyoto accounting period and is close enough to drive short-term emission reduction actions The longer-term target (2020–2021) is consistent with the Australian Government's target year and will drive ongoing action.
The target will be expressed in two ways: As emissions per square metre of gross floor area As an absolute percentage reduction from 2007 emissions	A benchmark figure for emissions per square metre of gross floor area was considered to be an equitable target that all universities could aspire to. The universities felt that floor space was more indicative of energy use than number of students or staff, given the different ways that each university operates. Emission intensity expressed in this way also allows planned building additions at each university to be taken into account when setting targets. An absolute percentage reduction is simpler to communicate to the public and guarantees a particular outcome, regardless of growth in gross floor area

The Emission Reduction Hierarchy

After several months of discussion, a preference for particular kinds of emission reduction emerged. The ERWG established the following order of preference for emission reduction options:

- Energy conservation, i.e. avoiding unnecessary emissions, for example through education and behaviour change programs. Examples include switching off lights and computers when not in use.
- Energy efficiency, i.e. modifying building systems and equipment to run more efficiently, which may include the upgrading of old systems to improve efficiency.
- Fuel substitution, i.e. switching to fuels with lower GHG intensity. This includes substitution of natural gas for grid electricity, purchase of GreenPower,[3] cogeneration, on-site or off-site generation of renewable energy and use of renewable transport fuels.
- Offsetting emissions using high-quality accredited emission offsets as a last resort to lower residual emissions that are unavoidable. Offsetting emissions was the least preferred option due to concerns about the legitimacy of offsets and a general principle that organizations should reduce emissions at source.

Scenario Modelling

Drawing on the GHG inventories, the agreed target characteristics and the emission reduction hierarchy, the authors developed a spreadsheet model to analyse multiple scenarios for the size of the target and the contribution of each university to achieving the target. The modelling included the following steps:

Identify existing university commitments to reduce emissions after the 2007 baseline year. Most universities had already made public commitments to reduce their emissions in various ways. These commitments will contribute towards meeting the ATN emission reduction target, and needed to be taken into account in the modelling of scenarios. Commitments fell into two categories:

- A commitment to purchase renewable energy (GreenPower) as a proportion of total electricity purchased
- A commitment to achieve a particular Green Star[4] rating in new or refurbished buildings.

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[3]GreenPower is a renewable energy accreditation program that allows customers to voluntarily pay extra on their electricity bills to support development of new renewable electricity sources. See www.greenpower.gov.au.

[4]Green Star is a comprehensive, national, voluntary environmental rating system that evaluates the environmental design and construction of buildings in Australia. The Green Star Education rating tool is specifically focused on schools and universities. Ratings of 4, 5 or 6 stars are possible under Green Star. See www.gbca.org.au.

Develop projections of GFA through to 2020–2021 based on future building development plans. Several of the universities were planning to embark on significant building projects that would add new floor space and refurbish existing floor space. While building refurbishment can reduce operational GHG emissions if the new building is more efficient, additions of floor space will always lead to an increase in total GHG emissions. The modelling needed to take into account all known additions, divestments, and refurbishments of floor space to arrive at an accurate understanding of projected future emissions.

Identify policy developments likely to have a significant impact on future emissions. The National Renewable Energy Target (NRET) is expected to increase the proportion of renewable electricity generation in Australia from 8% in 2008 to 20% in 2020. As a result, the emission intensity of grid electricity will decrease over time, which means that the emissions that each university is responsible for will also fall over time even in the absence of other action. This policy impact needed to be taken into account in the modelling.

Develop a "business as usual" (BAU) projection of GHG emissions through to 2020–2021. This projection was derived by applying assumed emission intensities to future additions of GFA. The emission intensities took into account any Green Star commitments made at each university. Projections were then adjusted to subtract emission reductions associated with GreenPower commitments and NRET. When existing university commitments, projected GFA, and the impact of NRET were taken into account, ATN emissions were projected to fall by 11% between 2007 and 2020.

Calculate the emission intensity (kg per m^2 of GFA) in 2020–2021 required to achieve particular absolute reduction targets, such as a 25 or 40% reduction in GHG emissions from 2007 levels.

This analysis resulted in a uniform benchmark emission intensity that each university would need to achieve to meet a given absolute reduction target. For example, a 25% reduction in absolute GHG emissions would require all universities to achieve an average GHG intensity of 105 kg per m^2 of GFA in 2020–2021. However, further analysis and negotiation was required to decide on each university's equitable contribution to the target.

Accounting for Differing Circumstances

The equitable distribution of targets across the five universities was a key discussion topic during the ERWG negotiations. There were three main reasons why universities felt that their specific circumstances needed to be taken into account in setting targets:

- Those universities with low emission intensity at present argued that they had already taken strong action in the past and other universities needed to catch up.

- Some universities were about to embark on major building programs and felt that they should not be penalised for this in the target setting process.
- The emission intensity of Australia's electricity supply varies significantly between states, so those universities in states with high emission intensity felt that this indicator penalized them.

The first issue above was addressed by requiring all universities to achieve the same GHG intensity for GFA by 2020–2021. Those universities that already had lower GHG intensity due to previous action will have less work to do to reach the target. The general approach is similar to the well-known contraction and convergence framework for international climate policy, in which nations are assigned equal per capita emission rights and must converge on these levels in a specified future year (Meyer 2001). In this variation, universities are required to converge on the same GHG intensity of GFA by a given year.

Expressing the target in this way also addresses the second issue, as an intensity target is independent of any growth in GFA at a particular university. So if a university does embark on a major building programme, it need only ensure that these new buildings meet or exceed the intensity target. It is important to note however that the intensity targets were intended to correspond to particular absolute reduction targets, so growth in GFA beyond the projections developed by each university threatens the achievement of the absolute targets.

The third issue was addressed by normalizing each university's emissions to take into account differences in emission intensity across states. Universities in states with high emission intensity had their GHG emissions adjusted downwards. The common GHG intensity target for 2020–2021 was then calculated based on the adjusted emissions.

When this approach was translated into specific university commitment, one university was already able to achieve its fair contribution to a 25% GHG reduction target under the BAU projection, without needing to take any action. Indeed, that university had some scope to increase its emissions above the BAU projection and still meet a 25% target.

The Target Negotiations

By this time, the date for announcement of an emission reduction target was rapidly approaching and the ERWG needed to negotiate a combined target that was acceptable to all parties. Very little data had yet emerged from the energy audits and this made accurate analysis of what each university would need to do to meet particular targets, and how much it would cost, impossible. However, the authors used preliminary data from the energy audits to assess the impact on projected emissions of implementing all measures identified in the energy audits. Initial indications were that the ATN could achieve a 25% reduction in GHG emissions by 2020–2021 by implementing energy audit measures alone. On this basis, the

ERWG agreed in November 2008 that the ATN should adopt at least a 25% reduction target and submitted this recommendation to the Vice Chancellor's of the five universities for consideration.

It was at this point that the negotiations began in earnest, as the Vice Chancellors and their senior advisers began to realise what was at stake. A substantial GHG reduction target would require substantial capital investment to realise energy savings identified in the energy audits. Although that investment would likely deliver good returns, it was a difficult commitment to make at a time of economic uncertainty. Senior university staff began to engage more closely with the ERWG and to demand more robust modelling of the financial impacts of proposed targets. Doubts began to emerge over the feasibility of achieving a 25% reduction target.

As more results emerged from the energy audits, a more robust financial analysis became possible. The financial analysis adopted the following assumptions:

Each university would implement two-thirds of the energy-saving measures identified in energy audits as the primary mechanism to meet the emission reduction targets. Limiting implementation to two-thirds of identified measures allowed for rejection of some of the measures if they proved to be impractical or if specific measures had a poor internal rate of return.

Actual results were used for those universities that had provided energy audit results. Where results had not been provided, an average from the other energy audits was used with proportional adjustment based on quantity of emissions.

A carbon price of $20/tonne was used to take into account avoided carbon costs associated with electricity savings.

If implementation of energy audit measures was not sufficient to achieve the target reduction at a particular university, the remaining reduction was achieved through purchase of GreenPower at a tariff premium of 7c/kWh. It is highly likely that cheaper fuel substitution measures will be available to each university; however, resources were not available for detailed costing of fuel substitution measures. The assumed purchase of GreenPower allowed an upper bound to be put on costs.

For the first time, this analysis presented each university with a feasible, costed strategy for meeting particular GHG targets. The final version of the analysis modelled 25 and 35% reduction targets and showed that three of the universities would need to purchase varying amounts of GreenPower before 2020, in addition to implementing energy audit measures, to achieve a 25% GHG reduction target. This information allayed the concerns of the Vice Chancellors and senior staff. The Vice Chancellors of the ATN universities made the following commitments on 9 February 2009:

Set a target for 2012–2013 of at least a 10% reduction in emissions below 2007 levels, with targets for each university varying from a 2 to 12% reduction.

Set a target for 2020–2021 of at least a 25% reduction in emissions below 2007 levels, which is equivalent to an ATN benchmark GHG intensity of 105 kg CO_2-e/m^2 per annum. Targets for each university varied from a 6% reduction to a 32% reduction.

Undertake an annual review of progress towards the greenhouse gas reduction targets.

Undertake a review every two years of the adequacy of the targets in light of changing scientific knowledge and the broader climate policy context. The first such review should be in 2010–2011.

Conclusion: Lessons for Other Universities

The previous sections have outlined the general approach used to set emission reduction targets for the ATN and the authors hope that other universities may be able to learn from this process. Additional lessons that are not evident from the process descriptions are outlined here.

First, coordinating multiple organizations separated by large distances to achieve a mutually beneficial outcome is exceedingly difficult. Telephone conferences are not an ideal platform for negotiation, as it is impossible to see body language and other non-verbal cues that help us to understand what a person is thinking and feeling. The small number of face-to-face meetings of the ERWG felt much more productive than the telephone conferences. Video conferencing may be a good compromise for other groups of universities embarking on a similar process.

Second, it is difficult to maintain momentum for a process like this in a university setting. All participants had to volunteer their time and fit the ERWG meetings into already busy schedules. The membership of the ERWG changed constantly over time as positions changed, senior staff became more or less engaged, or people sent delegates to meetings they could not attend. A significant proportion of each meeting was spent updating new participants on the process to date. Eventually, it was the focus provided by the deadline for the announcement of the ATN emission reduction target that provided the necessary momentum to see the process through to completion.

Third, while rigorous analysis of emission reduction strategies is appropriate, it is possible to get lost in the technical detail and lose sight of the original objective, which is to respond to the urgent problem of climate change. The analysis developed by the authors was only ever meant to be indicative and approximate, given the low quality of the input data. The intention was to give a clear sense of what the universities were committing to, while recognizing that each university would need to undertake its own detailed analysis to decide on its precise strategy for meeting the targets. Nevertheless, much time was spent debating minor modelling assumptions that had little impact on the overall conclusions.

Fourth, the importance of individual champions of climate change response within each university cannot be underestimated. Several of the ERWG members were strongly committed to this objective and kept the process moving when others would perhaps have been happy to let it fade away. As facilitators, one of the important roles for the authors was to identify these champions and find ways to engage them in the process to arouse the interest of other participants.

Finally, while there were strong attempts to ensure equitable distribution of targets across the five universities, the final result was unsatisfactory in this regard because an important factor was overlooked. Since the targets were set, it has emerged that operating hours are very different across the five universities. Some operate predominantly between 9 a.m. and 5 p.m., while others have a substantial programme of evening lectures and make laboratories available during the night. Longer operating hours lead to higher GHG emissions. As a result, GHG intensity per square metre of gross floor area is not an appropriate basis for equitable allocation of targets. University targets should also have been adjusted to take into account differences in operating hours. One university in particular benefitted from a lower target as a result of this omission.

Perhaps the most interesting lessons for the authors came from being involved in a very small-scale version of the type of negotiations that are taking place internationally as nations try to agree on global emission reduction targets. Although there were only five organizations involved, the negotiations mirrored the international negotiations in many ways. The participants sought an equitable distribution of the burden of climate change response, while arguing for their own special circumstances and the need for differentiation of targets to take these circumstances into account. It is interesting, though perhaps not surprising, that a contraction and convergence approach emerged as the only equitable way to provide differentiation of targets across the participants. Some authors (e.g. Garnaut 2008; Singer 2006) believe that such an approach is the only way to achieve a successful equitable outcome in international negotiations on climate change response and the ATN experience supports this conclusion. However, the key factor that allowed this approach to succeed in the ATN was the commitment of all parties to the ATN partnership and its spirit of collaboration. A similar spirit is sorely needed in international negotiations on climate change response.

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Chapter 13
Malaysian University Students' Awareness of Geographic Information Systems

Nor Rasidah Hashim and Mohd Fazlin Nazli

Abstract This chapter investigates the levels of GIS awareness and education of Malaysian university students. The objectives of our survey were to: (1) gauge students' knowledge of GIS and (2) gauge students' interest in GIS. The authors asked five questions to 96 students at Universiti Putra Malaysia. These students were from various faculties (Environmental Studies, Science, Computer Science & Information Technology, Biotechnology & Biomolecular Science, Medicine & Health Science, Modern Languages & Communication).

Most students, regardless of their year of study at the university, were not familiar with GIS, possibly because they had not taken any GIS course. A high percentage of the students (senior students, 94–100%; junior students, 89–98%) responded negatively to questions about their familiarity and knowledge of GIS. However, a majority of students showed high interest and had a positive opinion of GIS, i.e. as many as 74–80% of the junior students and 50–80% of the senior students answered "yes" to questions about their interest or usefulness of GIS. This study provides a clear indication that Malaysian university students are of the opinion that geospatial learning is interesting and important, which means the future of GIS in the country is bright.

Keywords Geospatial Skills · Geographic Information Systems · Malaysia

Introduction

Geographical information is information that relates to specific locations. In the 1980s there was a massive rise in research into computer systems that specifically handle geographical data. This interest and activity gave birth to Geographic Information Systems, GIS (Martin 1991; Goodchild 1992; Roberts and Betz 1999).

GIS has become very popular and thanks to GIS the field of geography has undergone a renaissance. Today GIS software has become so user-friendly that

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even computer users without any programming background can use the software. Internet-based GIS applications have also allowed people around the world to share and check out each other's locations and to monitor and analyse environmental data (wildlife, meteorological, and land use studies). And there are many job opportunities that are coming out of this situation, as Kenneth Field writes:

"The re-awakening of geography through the development of new technologies such as Google Earth, recreational GPS [global positioning systems], mobile map applications and in-car satellite navigation (to name a few), is whetting the appetite of a society that is ever more interested in location . . . Despite all this, there remains a shortfall of professionals and trained specialists" (Field 2008, p. 24).

In short, having GIS skills has become an added advantage for job seekers, who in many cases are university students. As such in this study, we aimed to find out the levels of GIS awareness and learning of Malaysian university students. Specifically, the objectives of our survey were to: (1) gauge students' knowledge of GIS (low or high) and (2) gauge students' interest in GIS (low or high).

Materials and Methods

In July–August 2007, we asked five questions (see Tables 1 & 2) to 96 students at Universiti Putra Malaysia (UPM), 46 of whom were in their first semester and the other 50 were in their senior years (year two and above), comprising 74 female students and 22 male students. Their ages ranged from 19 to 23 years. These students were from various faculties (Environmental Studies, Science, Computer Science & Information Technology, Biotechnology & Biomolecular Science, Medicine & Health Science, Modern Languages & Communication) but none was from the Engineering faculty or the Forestry faculty, both of which offer courses in GIS at the undergraduate level.

Results and Discussion

Most of the students, regardless of their year of study at the university, were not familiar with GIS, possibly because they had not taken any GIS course (question nos. 1, 2 & 3; Tables 1 & 2). A high percentage of the students (senior students, 94–100%; junior students, 89–98%) responded negatively to question nos. 1, 2 & 3 on their familiarity and knowledge of GIS. Our findings supported the suggestion made by Shariff and Shafri (2005) that "there is a general lack of awareness about this field [GIS] among the young people entering tertiary education . . . (2005, p. 3).

However, the majority of the students showed a high level of interest in GIS and had a positive opinion of GIS, i.e. as many as 74–80% of the junior students and 50–80% of the senior students answered "yes" to question nos. 4 & 5 (Tables 1 & 2). This latter set of results is indeed encouraging for Malaysian academia. These

Table 1 Students' answers to five questions about GIS knowledge and interest

No.	Question	No	Yes	No answer
1	Are you familiar with geographic information systems (GIS)?	43 (93%)	2 (4%)	1 (2%)
2	Have you taken a full course in GIS?	45 (98%)	0 (0%)	1 (2%)
3	Have you learned about GIS in any of your other courses?	41 (89%)	4 (9%)	1 (2%)
4	Do you think GIS is useful in your field of study?	10 (22%)	34 (74%)	2 (4%)
5	Are you interested in learning about GIS?	7 (15%)	37 (80%)	2 (4%)

The respondents were junior students (in their first semester of study) at UPM ($n = 50$)

Table 2 Students' answers to five questions about GIS knowledge

No.	Question	No	Yes	No answer
1	Are you familiar with geographic information systems (GIS)?	49 (98%)	1 (2%)	0
2	Have you taken a full course in GIS?	50 (100%)	0 (0%)	0
3	Have you learned about GIS in any of your other courses?	47 (94%)	3 (6%)	0
4	Do you think GIS is useful in your field of study?	24(48%)	25 (50%)	1 (2%)
5	Are you interested in learning about GIS?	6 (12%)	40 (80%)	4 (8%)

The respondents were senior students (second year and above) at UPM ($n = 46$)

results are also consistent with the report made by Shariff and Shafri (2005) that the MSc programme in GIS and remote sensing at the faculty of engineering, which was started in 1998, had been quite popular, which is to say that once the students have had enough basic skills and knowledge in GIS at the undergraduate level they would have the interest and confidence to pursue the field further.

This also means that Malaysian universities' curricula, especially for those fields that deal with the environment and human populations, need to include GIS courses. In this way Malaysian students have the opportunity to develop their geospatial knowledge and skills by learning GIS and other related technologies such as remote sensing applications and geographical positioning systems.

In fact the new and revamped Bachelor degree in environmental sciences at UPM (called Bachelor of Environmental Science and Technology, or BEST for short) has full courses in GIS and remote sensing, respectively. In order to offer these courses, the GIS laboratory of the environmental studies' faculty is equipped with several popular GIS commercial software and hardware (GPS hand-held units, map scanner, plotter, and tablet digitizer).

In light of our study's results, we make a note about the potential of GIS in enhancing other more traditional disciplines, e.g. geography and history. Perhaps, only two major universities in Malaysia still offer Geography as a major or a degree, namely Universiti Malaya and Universiti Kebangsaan Malaysia, whereas GIS is beginning to be taught in many institutions of higher learning across the country (Shariff and Shafri, 2005). This development is actually good for geography and its long-term survival. At the same time, GIS allows for a more innovative way to study other fields in the social sciences and humanities. Examples include the spatial analysis of historical maps and/or census data to expand the database for heritage conservation (Hashim and Yaacob 2007; Shahrudin and Hashim in prep.). By increasing the students' awareness of how GIS can enhance these other fields further interest can be garnered and eventually more creative research projects that utilize GIS and other associated technologies in the social sciences and humanities can be conducted in the country because the students are the nation's future professional researchers and academicians.

Conclusion

At this stage GIS is still relatively unknown amongst Malaysian university students. However, based on our survey the future of GIS in Malaysian universities seems bright but we suggest here that more needs to be done by GIS practitioners working in academia to make the future brighter.

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Chapter 14
Lifestyle Changes: Significant Contribution to GHG Emission Reduction Efforts

Dalia Streimikiene and Remigijus Ciegis

Abstract The EU initiated a campaign "You control climate change", which was launched in summer 2006. The campaign used TV, outdoor, and newspaper advertising, as well as a range of electronic tools, such as banners and emailings, to attract attention. There was a school student element as well – the Europa Diary for 2007–2008, with more than 2.3 million copies distributed throughout Europe, included a section on climate change and encouraged students to reduce their personal greenhouse gas emissions by making small changes to their daily behaviour.

Based on this idea, the goal was set to analyse the possibilities to reduce GHG emissions in our everyday life based on experiments carried out by the students at Vilnius University Kaunas Faculty of Humanities. The aim of the experiment was to calculate GHG emission reduction by one household during the year by changing life habits towards sustainable consumption and recording this daily. The Carbon Calculator available on the website developed by the EU campaign "You control climate change" was used to calculate how many kg of CO_2 can be saved each year by adopting lifestyle changes. The results of the exercise are described in this chapter.

Keywords Lifestyle changes · Energy saving · GHG emission reduction

Introduction

Fossil fuel burning is the main source of GHG emissions (Monbiot 2007). The major source of GHG in Lithuania is the energy sector, which is responsible for 61% of all GHG emissions (CO_2 equivalent in Gg), not taking into account removals/emissions from the LULUCF sector.

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Households make up one-third of the total energy consumption in the EU. Household greenhouse gas emissions are directly related to the amount of energy consumed in households. However, different fuel sources have different greenhouse gas intensities. For example, electricity used from coal-fired power stations is far more greenhouse-polluting than the usage of gas delivering the same amount of useful energy. Within each area of household energy use, there will be different strategies for the reduction of emissions through changes to the house fabric, changes in behaviour and purchasing, and energy conservation applied to existing appliances (Kellogg 1981).

Houses, appliances, and the energy type they use give rise to a huge variation in regional household emissions. Nationally, a typical household using predominantly electric appliances may contribute up to 10 tons of carbon dioxide per year while a house with many gas appliances may produce over 6 tons of carbon dioxide per year. According to AGO (1999), 1.29% of average household energy consumption is used for water heating, 16% by refrigeration, 14% by room heating and cooling, 8% for lighting, and over 7% for standby power (Pears and Greene 1999; Pears 1998).

However, few places are average and household consumption is determined by geographical region, income, climate and building stock as well as by personal behaviour and equipment (Aubin 2003). The right choices for residential measures can significantly reduce GHG emissions in households and help the country to achieve GHG emission reduction targets set by international commitments, including the UNFCCC Kyoto Protocol and following international climate change mitigation regimes after Kyoto.

Seeking to evaluate possibilities for households to reduce GHG emissions by changing lifestyle the comprehensive study was conducted by MSc programme students at Vilnius University Kaunas Faculty of Humanities. The main tasks of the study were:

- To conduct a daily survey of students' activities and record energy use and other habits based on two scenarios – baseline and GHG emission reduction scenario, including energy saving and evaluation of avoided GHG emissions in warm and cold periods of the year
- To evaluate GHG emission reduction by using the Carbon Calculator based on modified coefficients
- To evaluate GHG emission reduction potential in households and to compare with GHG emission reduction potentials in other sectors in Lithuania

The Framework for Assessment of GHG Emission Reduction Potential in Households

During the study conducted by MSc programme students at Vilnius University Kaunas Faculty of Humanities, the time spent for a specific activity is recorded and energy consumed (electricity, gas, petrol) is assessed for a baseline and GHG emission reduction scenario. Based on this data, energy consumed is multiplied by specific coefficients and GHG emissions for each activity are evaluated. Specific coefficients, obtained from the Carbon Calculator available on the website developed by the EU campaign "You control climate change", were used to calculate how many kg of CO_2 can be saved each year by adopting lifestyle changes. Having this data it is possible to evaluate GHG emission reduction potential in households in Lithuania, taking into account the population size of the country. The main uncertainties of this study and assessments are related to differences in population, income, and living standards, location, education, background, dependence on a specific social group, age, sex, profession, and concern about the environment: all have an impact on specific habits and lifestyles. The survey was conducted by students and therefore represents the habits of a specific social group. However, avoided GHG emissions for all households were evaluated in this study.

The cold year period is from 1 October to 31 March. The warm year period is accordingly from 1 April until 30 September. Energy saving is focused on lifestyle changes and is not related to investments in energy saving equipment or house insulation. Avoided GHG emissions can be achieved free of charge.

The main algorithm applied in GHG emission reduction potential assessment in households is presented below.

GHG emissions during half a year for the baseline scenario were evaluated based on the formula (1):

$$E_{1w} = S_{1w} * D_w * G \tag{1}$$

Here:

E_{1w} – GHG emissions in households according to baseline scenario during warm year period

S_{1w} – daily GHG emissions per capita during warm year period according to baseline scenario

D_w – the total amount of days during the warm year period

G – Population size adjusted to include disabled people and infants.

GHG emission during half a year according to GHG emission reduction scenario was evaluated based on the formula (2):

$$E_{2w} = S_{2w} * D_w * G \tag{2}$$

Here:

E_{2w} – GHG emissions in households according to GHG emission reduction scenario during the warm year period

S_{2w} – daily GHG emissions per capita during warm year period according to GHG emission reduction scenario

D_w – the total amount of days during the warm year period

G – Population size adjusted to include disabled people and infants.

Avoided GHG emissions in households during the warm year period as a result of energy saving and lifestyle changes are evaluated based on formula (3):

$$M_w = E_{1w} - E_{2w} \quad (3)$$

Here:

M_w – avoided GHG emissions during the warm year period

In an analogous way avoided GHG emissions were evaluated for the cold period of the year M_c based on formula (4):

$$M_c = E_{1c} - E_{2c} \quad (4)$$

Total avoided GHG emissions in households were evaluated by totalling GHG emissions avoided during the warm and cold year periods:

$$P = M_w + M_c \quad (5)$$

Here:

P – total annual GHG emission reduction potential in households because of energy saving and lifestyle changes.

In the following Table 1 the student daily activity records during the warm period are presented, according to the baseline scenario. In daily activity records the time, the main activities, and their duration is recorded. Based on these records the amount of energy used or waste accumulated is evaluated. Having this data it is possible to assess GHG emission from energy consumption or accumulated waste by applying specific GHG emission coefficients presented in Table 1.

The main coefficients applied in GHG emission assessment are presented in Table 2.

Based on information presented in Table 2, average daily GHG emissions per household during the warm year period amount to approximately 11.03 kg CO_{2eq} according to the baseline scenario. Total GHG emissions during the warm year period according to the baseline scenario are evaluated using formula (1):

$$E_{1w} = 11.03 \times 182.5 \times 3045000 = 2012.98 \times 3045000 = 6129508875 = kg \\ = 6.13\ Mt$$

GHG emissions during the same period according to the GHG emission reduction scenario were evaluated in Table 3. In the GHG emission reduction scenario students who conducted the daily survey were trying to adopt lifestyle changes to save as much energy as possible. The main lifestyle changes included using a bicycle or walking instead of driving a car, reducing waste by sorting and selecting appropriate packaging and buying intelligently, switching the light and computer or TV set off when not needed, turning off the tap while brushing teeth, using the shower instead of the bath and reducing time spent under the shower, not leaving appliances on standby, unplugging the mobile charger when it

Table 1 Daily activity records during the warm year period according to the baseline and GHG emission reduction scenario

Time	Activities	Duration, h	Amount of energy used or waste accumulated	Coefficient	Formula for GHG emissions assessment	GHG emissions, kg of CO_2 equivalent
10:00–10:30	Cooking	0.5	0.1 m^3	2.19	0.1*2.19	0.22
10:45–14:15	Use of PC	3.5	Processor–150 W Monitor–100 W Hard disk 30 W Optical disk–20 W Graphics card–100 W Sound card–30 W Hard disk–30 W Total: 460 W	1/2*	(3.5*460)/2*1,000	0.81
12:00–14:15	Watching TV	2.25	100 W	1/2*	(2.25*100)*2*1,000	0.11
14:30–18:45	Car driving (distance: 50 km)	4.25	5 L	1.64/2*	(5*1.64)/2	4.1
18:45–00:05	Lighting	5.33	5 × 100 W	1/2*	(5.33*500)/2*1,000	1.33
18:50–19:45	Cooking	0.92	0.17 m^3	2.19/2*	(0.17*2.19)/2	0.19
19:55–19:59	Waste	0.07	1 kg	1/2*	(1*1)/2	0.5
20:00–23:30	Use of PC and TV set	3.5	460 W	1/2*	(3.5*460)2*1,000	0.81
23:35–23:52	Use of shower	0.28		0.174	17*0.174	2.96
						11.03

Table 2 GHG emission coefficients

Coefficient	Description
2.193	This coefficient was applied for the evaluation of GHG emissions during cooking. It indicates the amount of GHG emissions by burning 1 m^3 of natural gas
1	This coefficient is applied for the evaluation of GHG emissions during consumption of electricity. It indicates the amount of GHG emissions during 1 kWh of electricity consumption
1.64	This coefficient was applied for the evaluation of GHG emissions during car driving. It indicates the amount of GHG emissions during 1 km of car driving. It is assumed that to drive 10 km 1 L of petrol is necessary.
1	This coefficient was applied for the evaluation of GHG emissions because of waste accumulation in households. It indicates the amount of GHG emissions because of 1 kg waste accumulation.
0.174	This coefficient was applied for the evaluation of GHG emissions during warm water consumption. It indicates GHG emissions for 1 min of showering at water speed 0.28 L/min.

Table 3 Daily activity records during the warm year period according to the GHG emission reduction scenario

Time	Activities	Duration, h	Amount of energy used and waste accumulated	Coefficient	GHG emissions, kg of CO_2 equivalent
10:00–10:30	Cooking	0.5	0.1 m^3	2.19	0.22
10:45–12:15	Use of PC	1.5	460 W	1/2*	0.35
12:00–13:00	TV watching	1	100 W	1/2*	0.05
13:00–14:45	Car driving (distance 15 km)	1.25	1.7 L	1.64/2*	1.23
14:45–18:45	Cycling	4	0	0	0
19:05–00:05	Lighting	5	4 × 100 W	1/2*	1
18:50–19:45	Cooking	0.92	0.17 m^3	2.19/2*	0.19
19:55–19:59	Waste	0.07	0.8 kg	1/2*	0.4
20:00–22:30	Use of PC and TV set	2.5	460 W	1/2*	0.58
23:35–23:45	Shower	0.16		0.174	1.74
Σ CO_2 emissions, kg					5.76

is not being used, boiling less water when cooking, covering pots while cooking, etc. These simple lifestyle changes, described in detail on the website http://ec.europa.eu/environment/climat/campaign/index.htm, can avoid quite large amounts of GHG emissions, as can seen in Table 3.

Total GHG emissions during the warm year period according to the GHG emission reduction scenario after energy-saving and waste-reduction measures were applied were evaluated using formula (2):

$$E_{2w} = 5.76 \cdot 182.5 \cdot 3045000 = 1051.2 \cdot 3045000 = 3200904000 \text{ kg} = 3.2 \text{ Mt}$$

Therefore, avoided GHG emissions in households during the warm year period as a result of energy saving and lifestyle changes are evaluated based on formula (3):

$$M_w = 6.13 - 3.2 = 2.93 \text{ Mt}$$

Daily records and evaluated GHG emissions in households during the cold year period according to the baseline scenario are presented in Table 4.

As can be seen in Table 4, GHG emissions during the cold year period are higher, as a result of longer periods of lighting and higher electrical appliance use. Total GHG emissions in households according to the baseline scenario during the cold year period were evaluated for the cold period using formula (1):

$$E_{1c} = 12.33 \cdot 182.5 \cdot 3045000 = 2250.23 \cdot 3045000 = 6851935125 \text{ kg} = 6.85 \text{ Mt}$$

Daily records and evaluated GHG emissions in households during the cold year period according to the GHG emission scenario are presented in Table 5.

Total GHG emissions in households according to the GHG emission reduction scenario during the cold year period were evaluated for the cold period using formula (2):

$$E_{2c} = 7.43 \cdot 182.5 \cdot 3045000 = 1355.98 \cdot 3045000 = 4128943875 \text{ t} = 4.13 \text{ Mt}$$

Therefore, avoided GHG emissions in households during the cold year period as a result of energy saving and lifestyle changes are evaluated based on formula (4):

$$M_c = 6.85 - 4.13 = 2.72 \text{ Mt}$$

Table 4 Daily activity records during the cold year period according to the baseline scenario

Time	Activities	Duration, h	Amount of energy used and waste accumulated	Coefficient	GHG emissions, kg of CO_2 equivalent
09:00–09:45	Cooking	0.75	0.135 m^3	2.19	0.3
10:00–14:00	Use of PC	4	460 W	1/2*	0.92
11:00–14:00	TV set	3	100 W	1/2*	0.15
14:10–16:45	Car driving (distance 50 km)	2.58	5 L	1.64/2*	4.1
16:45–00:05	Lighting	7.33	5 × 100 W	1/2*	1.83
18:00–19:30	Cooking	1.5	0.27 m^3	2.19/2*	0.3
19:45–19:50	Waste	0.08	1 kg	1/2*	0.5
18:00–23:30	Use of PC and TV set	5.5	460 W	1/2*	1.27
23:35–23:52	Shower	0.28		0.174	2.96
Σ CO_2 emissions kg					12.33

Table 5 Daily activity records during the cold year period according to the GHG emission reduction scenario

Time	Activities	Duration, h	Amount of energy used and waste accumulated	Coefficient	GHG emissions, kg of CO_2 equivalent
09:00–09:45	Cooking	0.75	0.135 m^3	2.19	0.3
10:00–13:00	Use of PC	3	460 W	1/2*	0.69
11:00–13:00	Watching TV	2	100 W	1/2*	0.1
14:10–16:00	Car driving (distance 17 km)	2.58	3 L	1.64/2*	1.39
16:45–00:05	Lighting	7.33	4 × 100 W	1/2*	1.47
18:00–19:30	Cooking	1.5	0.27 m^3	2.19/2*	0.3
19:45–19:50	Waste	0.08	0.8 kg	1/2*	0.4
19:00–23:30	Use of PC and TV set	4.5	460 W	1/2*	1.04
23:35–23:45	Shower	0.16		0.174	1.74
Σ CO_2 emissions, kg					7.43

Total avoided GHG emissions in households as a result of lifestyle changes and saving energy and reducing waste are evaluated based on formula (5):

$$P = 2.93 + 2.72 = 5.65 \text{ Mt}$$

Evaluation of GHG Emission Reduction Potential in Lithuania

The results of a study conducted by MSc Programme at Vilnius University Kaunas Faculty of Humanities indicated that total annual GHG emissions in Lithuanian households according to the baseline scenario amounted to 12.98 Mt. The approximate annual GHG emission reduction potential as a result of lifestyle changes and saving energy and reducing waste is about 5.65 Mt in Lithuania. In the national energy efficiency programme adopted in 2007 (Ministry of Economy of Republic of Lithuania 2007), the total annual GHG emission reduction potential evaluated in the household sector was just 1.312 Mt CO_{2eq} and is significantly lower.

There are already climate change mitigation policies and measures implemented in Lithuania which mainly target increased use of renewable energy sources and energy efficiency improvements in industry and the energy generation sector (Streimikiene et al 2006). GHG emission reduction potential evaluated in Lithuania in a report demonstrating progress under the Kyoto Protocol (Ministry of Environment of the Republic of Lithuania 2008) is presented in Table 6.

Table 6 Impact of policies and measures in 2010, 2015, 2020 and 2025, Mt (Ministry of Environment 2008)

Climate change mitigation policies and measures	Average annual GHG emission reduction, Mt			
	2010	2015	2020	2025
Fuel combustion sector				
Energy savings	0.18	0.51	0.84	1.18
Use of waste energy resources (conversion factor to primary energy 0.5)	0.22	0.3	0.38	0.45
Use of biofuels in transport (conversion factor to primary energy 1.076)	0.17	0.32	0.47	0.62
RES in electricity generation (conversion factor from electricity to primary energy 2.707)	0.54	0.66	0.78	0.9
Cogeneration (conversion factor to primary energy 0.5)	0.29	0.36	0.43	0.51
RES in primary energy supply except categories already mentioned	0.5	0.61	0.72	0.84
Total in fuel combustion sector	1.9	2.79	3.62	4.5
Agriculture				
State programme to reduce water pollution from agricultural sources	0.7	1.2	1.7	2.2
Waste				
National strategic waste management plan	0.94	0.31	0.81	2.44
Industrial processes				
Wet cement production technology replacement by dry cement production technology	0.5	0.5	0.5	0.5
Modernization of technological processes in chemical industries of Achema	1.9	1.9	1.9	1.9
Total in industrial sector	2.4	2.4	2.4	2.4
Forestry Expansion Strategy for 2004–2020	7	7.63	8.26	8.9
LULUCUF				
Total with LULUCUF	12.9	14.3	16.79	20.44
Total without LULUCUF	5.94	6.67	8.53	11.54

The annual GHG emission reduction potential in the fuel combustion sector in 2010 is just 1.9 Mt, in industry, –2.4 Mt. The total GHG emission reduction potential in Lithuania in 2010 is about 5.94 Mt without LULUCUF. Therefore, the total evaluated GHG emission reduction potential in Lithuania is very close to possible GHG emission reduction in households as a result of energy saving and waste reduction −5.65 Mt.

In Lithuania, because of the closure of the second unit at Ignalina NPP in 2009, it is expected that GHG emissions will increase by about 5 Mt/year (Ministry of Environment of the Republic of Lithuania 2006). There is a plan to build a new nuclear power plant in Lithuania in 2015–2017. Construction of a new nuclear power plant in Lithuania would allow a reduction of GHG emissions by 5–6 Mt/year, which means it is not necessary to build a new nuclear power plant seeking to reduce increased GHG emissions because of the closure of the second unit of

Ignalina NPP (Lithuanian National Energy strategy 2007). First of all, cheap or cost-measures should be implemented in household sector which would help significantly to reduce GHG emission in the country.

Conclusions

The annual GHG emission reduction potential in households based on the national energy efficiency programme (Ministry of Economy of Republic of Lithuania 2007) is about 0.52 TWh. Evaluated GHG emission reduction potential in the household sector is 1.312 Mt CO_2 per year in Lithuania, according to this document; however, the study conducted by MSc programme students of Vilnius University Kaunas Faculty of Humanities indicated that the lifestyle changes can allow a reduction of GHG emissions in households without any additional investments of about 5.65 Mt.

Concerted action in the residential sector can achieve significant greenhouse gas reductions. While the approaches are easily encouraged, they also need to be quantified accurately to balance against reduction targets. It is necessary to inform residents about simple cheap or cost-measures, allowing saving of energy and reduction of GHG emissions in households.

The evaluated total annual GHG emission reduction potential in Lithuania in 2010 is about 5.94 Mt without LULUCUF. Therefore, the total evaluated GHG emission reduction potential in Lithuania is very close to the possible GHG emission reduction in households as a result of energy saving and waste reduction −5.65 Mt.

In Lithuania, because of the closure of the second unit at Ignalina NPP in 2009, it is expected that GHG emissions will increase by about 5 Mt/year. There is a plan to build a new nuclear power plant in Lithuania in 2015–2017. Construction of a new nuclear power in Lithuania would allow a reduction in GHG emissions of 5–6 Mt/year; therefore it is not necessary to build a new nuclear power plant seeking to reduce increased GHG emission because of the closure of the second unit of Ignalina NPP. First of all, cheap or cost-measures should be implemented in the household sector which would help significantly to reduce GHG emissions in the country.

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Chapter 15
Universities as Learning Organizations for Sustainability? The Task of Climate Protection

Florian Lüdeke-Freund and Simon Burandt

Abstract For two decades the Leuphana University of Lüneburg has addressed socio-ecological issues in research, education and administration. Realizing projects such as "Agenda 21 and University of Lüneburg" (1999), "Sustainable University" (2004) and its mission statement of "Carbon-Neutral University" (2007) entails non-trivial organizational changes. Creating an authentic "Carbon Neutral University" induces multi-level learning and decision problems within the organization. Concepts of organizational learning are considered as most promising approaches to analysing and understanding sustainability-oriented projects.

Past, present, and future sustainability projects are explored in this chapter. An organizational learning perspective is applied in order to identify specific phases and mechanisms of organizational developments towards realizing the university's mission statements. Empirical facts are discussed against the theoretical background of organizational learning. A conceptual perspective is developed for organizational learning in complex fields such as sustainable development.

Keywords Organizational learning · Sustainable development · Carbon Neutral University

Introduction: Sustainable Development and Universities

Universities have always played an important role in and for society. During the last few decades, a change could be observed in both the organization and the role of universities: Universities are professionalizing and are becoming further integrated into society. At the same time, society is increasingly questioning universities; hence they are confronted with a greater need for accountability to society in general and their specific stakeholders in particular. Nowadays, universities cannot hide from their obligation to contribute to one of the major challenges the world is facing: sustainable development (Albrecht 2009).

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With regard to sustainable development, universities act on different levels: on the one hand, science, research and technical developments contribute to global change and progress – entailing quite noteworthy environmental impacts, e.g. from inventions, energy consumption or scientists' travelling (Adomßent et al 2008b). On the other hand, they are a driver for finding solutions to face unsustainable development by exploring new research questions, problem orientation, technical advancement, and the reflection of research results.

Sustainability challenges require integrated interdisciplinary solutions and people with the relevant skills to take necessary action. We are confronted with growing complexities in terms of an explosion of knowledge and information and, at the same time, with growing uncertainties (Adomßent 2004). Teaching in universities can contribute to sustainable development by fostering interdisciplinary and transdisciplinary views (Barth et al 2007). Consequently, interdisciplinary and transdisciplinary teaching and research cultures are indispensable and have to be discussed in the context of sustainability (Grunwald and Ott 2005).

On a normative level, universities as organizations with significant societal impacts can act as role models or catalysts for sustainable development. Therefore, it is necessary to comply with the criteria of sustainable development in areas such as organization, professional culture, and understanding of science (Kehm and Pasternack 2000). On the organizational level, implementing sustainability as a guiding principle can be viewed as a considerable driver for organizational change (Wals and Corcoran 2006; Albrecht et al 2007).

Altering environments, e.g. in terms of shifting paradigms such as sustainable development and changing societal needs, requires organizational change through organizational learning (Schreyögg 1999). Universities have to adjust their organization as well including instrumental and institutional aspects and derivates such as structures, processes, and cultures.

Generally, a certain learning aptitude is the prerequisite for organizational change and learning. In the following, universities will be investigated as learning organizations and possible barriers to learning will be introduced theoretically. Against this background organizational developments and activities of the Leuphana University of Lüneburg towards becoming a sustainable university are discussed with special focus on efforts to become a carbon-neutral university.[1]

The Purpose of Organizations

Organizations frame individual behaviour and give internal and external shapes to complex systems (Schreyögg 1999). Organizations also bundle power and capacities to multiply and expand individuals' outputs. Therefore, an essential task is to

[1] http://www.leuphana.de/nachhaltigkeitsportal/klimaneutral.html.

provide for coordination and cooperation among individuals and units under a common objective. Management acts in response to the challenge "to align the interests of individuals with those of the organization (the cooperation problem) and to harmonize individuals' actions (the coordination problem)" (Grant 2009, p. 7).

This view cannot be transferred directly to universities. Due to their historical origins and structures universities do not follow common objectives on the "practical" level. They are "political organizations" that do not draw legitimacy from practical actions like "action organizations" do (Weick 1988; Brunsson 1989). However, organizations can be loose and coupled systems at the same time (Weick 1988). Professionalized universities fit this description by having a university management and administration that are coupled, whereas the distributed units in the scientific area are usually not. Additionally, when universities are facing real world problems, such as opening up to society or working on sustainable development, they become (at least partly) "action organizations" – i.e. they draw legitimacy on the "practical" level as well (Albrecht et al 2007). To contribute to a central purpose, the actions of individuals as well as (loose and coupled) systems within universities have to be aligned and harmonized.

Hence, from a management perspective universities can be seen as loose and coupled organizations (Weick 1988) facing the cooperation and coordination problem (Grant 2009) under special circumstances. Consequently, universities have to pass complex learning processes to improve performance and to adapt to changing environments and demands. But universities face specific barriers and challenges for learning processes due to their special character. In this article three different mechanisms are discussed as "theoretical enablers" for organizational learning against the specific background of the Leuphana University of Lüneburg (LULG).

Organizational Learning at the Leuphana University of Lüneburg as a Contribution to Sustainable Development

In the following, the development of the LULG will be introduced and reviewed, (a) with a special emphasis on approaches to implementing the guiding principle of sustainability, and (b) from an organizational learning perspective that distinguishes different theoretical learning mechanisms. An adequate scheme can be found in Winter 1997 (22–27) who discusses three basic mechanisms of organizational learning. Organizational learning can be based on:

- Formalization and institutionalization
- Shared knowledge and organizational maps
- Distributed learning and knowledge

The timeline of sustainability-related activities from the years 2000–2009 (see Table 1 next chapter) serves as a background for identifying the different phases of organizational learning. These phases can be characterized in terms of the

Table 1 Milestones towards Becoming a Sustainable University

Event	Year
Faculty of Environmental Sciences founded	1996
COPERNICUS University Charter for Sustainable Development signed	1997
Project "Agenda 21 and University of Lüneburg" started (until 2001)	1999
Working group "Environment" implemented	2000
"Guidelines for Environmental Protection" passed by senate	
EMAS validation of main campus	
Annual Environmental Declaration released for the first timereleased for the first time	
Lüneburg Declaration adopted during the international conference "Higher Education for Sustainability – Towards the World Summit on Sustainable Development (Rio+10)"	2001
Environmental Coordination nominated	2002
Working group "Health-Management" implemented	2003
Project "Sustainable University – Sustainable Development in the Context of University Remits" started (until 2007)	2004
UNESCO Chair "Higher Education for Sustainable Development" based at the "Institute for Environmental and Sustainability Communication" (INFU)	2005
"SoLue" ("Solar Project University of Lüneburg") realized 7.5 kWp photovoltaic facility	
Faculty of Environment and Technology founded	2006
Mission statement to become a carbon-neutral university by 2012	2007
Sustainability Report 2005/2006 released ("Steps towards the Future")	
Emphasis on sustainability sciences in future development plans, strengthening of department "Sustainability Sciences"	2008
Representative for Climate Protection nominated	
"Interdisciplinary Working Group Carbon Neutral University" implemented, platform for energy-related activities	
UniSolar Initiative Lüneburg founded	2009

abovementioned mechanisms. The authors argue that differentiating these ways of organizational learning is a valuable theoretical heuristic method for the purposes of description and interpretation. The analysis also shows that these mechanisms are interwoven in practice.

The Case of Leuphana University of Lüneburg

The LULG has recognized and accepted the need to engage in sustainable development quite early as one of the first universities worldwide and is now facing sustainability challenges in both the core activities of research, education and transfer, and in daily working processes. Some milestones in the development towards becoming a sustainable university are shown in Table 1.

An important step for climate protection was the adoption of the objective to become a carbon-neutral university by 2012.[2] Focal points of activities refer to

[2]The university's main campus was already carbon neutral in 2007 (http://www.leuphana.de/nachhaltigkeitsportal/klimaneutral/konzept.html).

energy supply, consumption, and mobility. Currently the LULG is developing a vast portfolio of internal activities to reduce and compensate for its CO_2 emissions.

This portfolio combines approaches from diverse fields of research and education. Existing as well as future infrastructures are subject to investment plans and organizational developments. An example is the development of a research project on energy management systems based on Ambient Assisted Life and IT approaches combined with perspectives from social sciences.[3] Moreover, the Institute of Ecology and Environmental Chemistry and the Representative for Climate Protection initiated research concerned with an integrated energy supply including maximum shares of renewable energies on campus. In the field of education a special seminar concept was set up for 2007 and 2008: several seminars were carried out by staff and students who analysed CO_2 sources and investigated possibilities of mitigation. A technical weakness analysis was carried out and improvements were implemented. For example, the university uses special energy-saving lamps almost everywhere, illumination is controlled by photoelectric switches, and heating is adjusted to the usage of buildings (especially during the Christmas break, weekends and public holidays).

For years several campaigns have been realized to raise users' awareness and to foster responsible energy consumption. As a result more than 6% of energy was saved throughout the campaign "nix-verschwenden" ("don't squander") that mainly focused on giving feedback on the energy demand by visualizing daily data at highly frequented points on campus (Adomßent et al 2008a, p. 41ff).

The challenging demand of "carbon neutrality" should be reached within the years 2007–2012. All sites (including all types of mobility) are planned to be carbon neutral in accordance with further structural developments of the university and the mission statement of being a sustainable university.

After this brief introduction to the LULG an analytical perspective is taken according to three different theoretical mechanisms of organizational learning: formalization and institutionalization, shared knowledge and organizational maps, and distributed knowledge and learning.

First Phase: Formalization and Institutionalization

After signing the COPERNICUS Charter[4] in 1997 an environmental working group was implemented in 1999 to tackle questions of environmental protection. Central fields of action were identified and foundations for a professional environmental management system (EMS) were laid. Energy, in terms of electricity and heat, and

[3] http://www.leuphana.de/institute/forschungsgruppe-vaust/vaust.html.

[4] The "COPERNICUS University Charta for Sustainable Development", set up in 1993, defined the role and principles of university action in the context of sustainable development (http://www.iisd.org/educate/declarat/coper.htm).

energy-related CO_2 emissions made up one out of ten major fields identified.. The second field of importance for climate protection was traffic, including commuter traffic and official trips. In the following year the senate passed its first environmental declaration including official Guidelines for Environmental Protection[5] and the announcement of a successfully implemented EMS (LULG 2000). This declaration aimed at increasing awareness and at permanently integrating environmental protection into the university's structures and processes. Consequently, the environmental management system was validated according to EMAS for the first time in 2000. To sum up, the environmental declaration and the implementation of an EMS were the formal foundations for the university's sustainability policy (Albrecht et al 2007). Today the LULG officially stands on three normative pillars: humanism, sustainability, and action orientation (LULG 2007). Obviously, the guiding principle of sustainability is now located on the top level of normative orientations.

These steps contributed significantly to the development of cognitive preconditions for integrating social and environmental aspects in a long-term scope. From an organizational learning perspective the formalization of normative guidelines and technical skills on how to deal with environmental issues is one possible approach of storing knowledge independently from individuals (Jelinek 1979; Bea and Göbel 2006). Accordingly, March and Olsen (1976, p. 157) constitute: "Normally it is argued that organizations try to perpetuate the fruits of their learning by formalizing them." Hence, this early stage can be characterized by *formalization and institutionalization* of environmental protection.

Figure 1 describes formalized knowledge as the organizational basis for environmental and climate protection. It is available as guidelines or management systems via regular administrative channels.

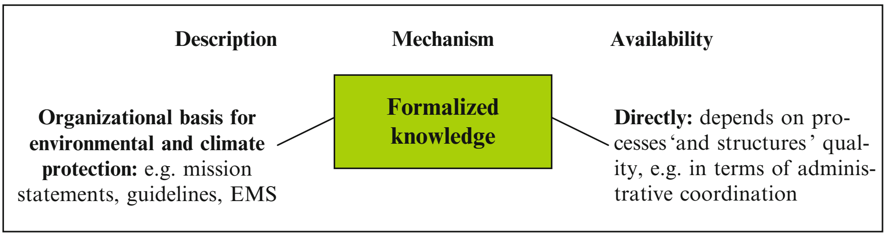

Fig. 1 Formalized knowledge

[5]Available online, http://www.leuphana.de/fileadmin/user_upload/uniprojekte/Umweltmanagement/files/Umwelterklaerung/ue_2000.pdf.

Second Phase: Shared Knowledge and Organizational Maps

What Argyris and Schön (1978) call an “organizational map” refers to the assumption that, theoretically, all members of an organization share a common knowledge basis. The implication is not that individuals possess identical cognitive structures, but that enough similarities exist to avoid significant frictions (Zahn and Greschner 1996). The organizational knowledge basis – represented by implicit knowledge (“tacit knowledge”; values, norms, experiences) and explicit knowledge (“articulated and codified knowledge”; forms, data storage) (Zahn and Greschner 1996; Argyris 1999; Schreyögg 1999) – is principally available for organizational decision processes.

Learning happens individually and contributes to superior “shared frames of reference” (Jelinek 1979; Hedberg 1981). These frames can be interpreted as shared mental models that consist of a collective *Weltanschauung* and organizational routines (Kim 1993). Following Kim’s learning theory, individual knowledge creation is influenced by the organization’s shared mental model and vice versa. Hence, the organization must at first be capable of integrating new and deleting old knowledge, and second, it should be able to realize changes which may result from the intertwined processes of individual and organizational knowledge creation (Zahn and Greschner 1996). Levitt and March (1988) refer to the necessary ability of “meta learning” in terms of “learning to learn” to successfully assimilate (single-loop learning) and accommodate (double-loop learning) knowledge (Kim 1993; Zahn and Greschner 1996).[6] At this point it is helpful to follow Örtenblad (2004, p. 57; original emphasis) who summarizes: “However, most authors who have written about ‘organizational learning’ seem to agree that *both* the individuals and the organization learn. The employees learn as agents for the organization, and the knowledge is stored in the memory of the organization. The memory consists of routines, dialogue or symbols – i.e. knowledge is embedded, encultured or encoded.”

The question arises: How did routines, dialogues, and symbols change at the LULG on its way towards becoming a sustainable university?

Since the late 1980s environmental topics were subject to research and education at LULG; in 1996 the faculty of environmental sciences was founded. Hence, research and education were the first areas in which knowledge on environmental issues was systematically created. Because of the wide dissemination of results of research and education throughout the university, the creation of new kinds of shared knowledge was possible. In the following formalization phase, guidelines were passed which influenced the university’s education and research culture. Four out of ten principles refer directly to the

[6]The learning hypotheses of single-loop and double-loop learning play a significant role in the field of organizational learning. Due to limited space this discussion has to be rescheduled; a contribution worthy of consideration is Kim 1993.

creation of organizational maps related to environmental protection (LULG 2006, p. 6; translated):

Principle 6: "In its curricula the university offers manifold possibilities for students to work on topics and problems of environmental protection on their own authority [. . .]"

Principle 7: "Environmental protection on a regional, national, and international scale is part of research activities [. . .]"

Principle 8: "Employees are frequently included in discussions on the realization of the 'Guidelines for Environmental Protection' [. . .]"

Principle 10: The public is being informed about environmental activities via dialogues. Realized measures are being communicated to external stakeholders and their ideas are being integrated [. . .]"

These principles intend to stimulate sustainability-oriented behaviour and processes of knowledge generation in several dimensions. Employees, researchers, students and external stakeholders are directly addressed regarding their working attitude, research orientation, education programme, and possibilities to engage actively. Since global attentiveness throughout the institution is a critical precondition for creating new organizational maps (Bea and Göbel 2006) the university's environmental coordination uses diverse communication channels: e.g. mailings, letters, posters, postcards, a sustainability portal on the Internet, visual presentations at highly frequented places on campus, an annual environmental declaration, and a biannual environmental or sustainability report.

Figure 2 describes collective knowledge as a common basis shared by the university's members. In the case of climate protection, such knowledge refers to general individual and organizational activities. It is available if the organizational knowledge flows through the institution and if individual learning can contribute to it.

Here it is argued that new kinds of *shared knowledge and "organizational sustainability maps"* from the 1980s and 1990s were crucial for formalization and institutionalization in the years 1999–2001. In turn, the latter was a prerequisite for current sustainability-oriented attitudes throughout the institution. How is this "fertile ground" used and developed further in the present?

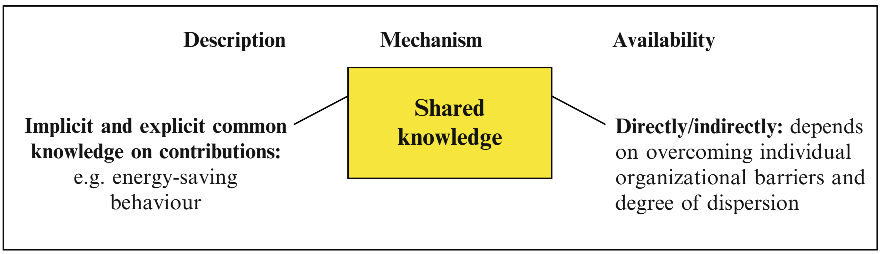

Fig. 2 Shared knowledge

Example: Research Project Sustainable University (2004–2007)
To review possibilities and barriers in implementing the overall concept of sustainability into university operations, an extensive and widely visible research project was conducted from 2004 to 2007. The status quo of all campus community members' attitudes and opinions regarding sustainability was reflected. "Findings indicate that campus community members are highly receptive to the notion of sustainable development; this suggests that there is high potential on campus to develop sustainability as a guiding principle for the university. These results are a fertile ground to expand sustainability initiatives on the way towards a sustainable organization." (Adomßent et al 2007)

The reception of sustainable development in the university context can be illustrated with numbers generated in the project (Adomßent et al 2007, pp. 2–3; translated):

- "Nearly 90% of those questioned are aware of the term 'sustainable development'"
- "Approx. 86% associate 'caring for future generations' with sustainable development"
- "Approx. 83% agree that universities should have a widely accepted guiding principle"
- "80% agree that environmental protection is a trademark of the university"

Third Phase: Distributed Learning and Knowledge

Current activities under the guiding principles of sustainable university and carbon-neutral university are used to illustrate how the organizational sustainability map may stimulate innovative learning processes to contribute to climate protection. The mechanism "distributed learning and knowledge" will be introduced against the background of activities aiming at the installation of photovoltaic facilities on campus.

Kirsch (1990) defines organizational learning as usage, change, and further development of the organizational knowledge basis. In other words, given pools of shared knowledge can be subject to changes and development initiated by individual learning – this does not happen as a concerted action, but on different levels and under different circumstances (Winter 1997). The third mechanism discussed in this article is based on differently scaled distributed learning processes and distributed pieces of knowledge on different levels throughout an organization. Pawlowsky (1994) refers to levels of intra-personal (inside individuals), inter-personal (between individuals) and intra-organizational learning (inside of the organization). Winter (1997) also mentions inter-organizational (between organizations) learning as a consequence of networks and cooperation on the level of organizations (Hamel 1991; Pawlowsky 1994; Schreyögg and Noss 1995). COPERNICUS can be interpreted as an example of inter-organizational learning.

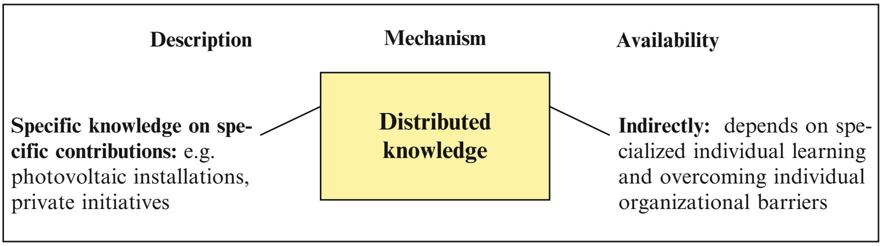

Fig. 3 Distributed knowledge

Figure 3 describes distributed knowledge. This learning mechanism is potentially the most fruitful as individual specialists on several levels create solutions for organizational problems (therefore the box is of bigger size than in Figs. 1 and 2). It is available if the specialized individual knowledge creation finds channels (in terms of overcoming e.g. administrative barriers) to contribute to organizational decisions.

Two examples of inter-personal and intra-organizational learning are illustrated in the following: "SoLue" (2005) and "UniSolar Lüneburg" (2009) (see Table 1).

The mechanism of *distributed learning and knowledge* was crucial for realizing the SoLue project in 2005. The university's ability to deal with the increasing complexity of the UniSolar Lüneburg approach will be decisive for enabling next-generation photovoltaic projects on campus. UniSolar Lüneburg still is an open process that might change at any time.

Example: Initiative "SoLue" (2005–2009)[7]

"SoLue" was founded in 2005 by students and employees. The purpose was to enable a network of university members and supporters (inter-personal level) to bring forward sustainability-oriented projects. A great success was the installation of a 7.5 kWp photovoltaic facility in December 2005. Part of the investment was made by university members and other private persons; the university accounted for the lion's share of the investment. In cooperation with the president's board, administration and environmental coordination (intra-organizational level) internal structures and processes were arranged to install and run the facility. In terms of organizational learning, the initiative's members – amateurs at first – had to acquire knowledge and skills to build up and run a private initiative. They also had to obtain and coordinate internal and external knowledge on photovoltaic technologies. Finally, the facility was realized by a professional solar installation company and was entrusted to the university who acts as operator. SoLue was disbanded in June 2009.

[7] http://www.solarprojekt.uni-lueneburg.de.

Example: "UniSolar Lüneburg" (beginning 2009)[8]

In 2007 the Centre for Sustainability Management (CSM) started a series of seminars on evaluating the status quo and developing concepts for possible measures from a management point of view. Students from the carbon-neutral university (2007/2008) seminars worked out a vast analysis of renewable energies, energy saving and mobility on campus (Beyer et al 2008). The following seminars titled "Foundation of the UniSolar Initiative Lüneburg" (2008/2009) were carried out in order to expand the successful SoLue approach. The idea behind UniSolar Lüneburg is to realize a project many times bigger than SoLue. As the legal frame changes continuously (decreasing feed-in tariff) UniSolar Lüneburg and the Interdisciplinary Working Group Carbon Neutral University (see Table 1) are preparing a concept to install maximum amounts of photovoltaic capacities on campus. From an organizational learning perspective, specific knowledge has to be acquired on the intra-personal level (e.g. Representative for Climate Protection, solar power specialist at the Institute for Ecology and Environmental Chemistry), on the inter-personal level (e.g. UniSolar Lüneburg, Interdisciplinary Working Group), and on the intra-organizational level (e.g. in-between the Environmental Coordination, the Interdisciplinary Working Group and the president's board). In contrast to SoLue, UniSolar Lüneburg needs to mobilize vast private investments, develop a case-specific business and operator model, and finally the whole concept has to be integrated into the university's processes and structures.

Conclusion: Sustainability Projects as a Means to Overcome Barriers of Organizational Learning?

Three main challenges can be identified in the organizational learning literature (Steinmann and Hennemann 1997): securing the application of existing knowledge; collectivizing individual knowledge; permanent triggering of individual learning. The authors argue that the above prescribed mechanisms are crucial for meeting these challenges.

Figure 4 suggests a starting point for an appropriate reflection process. The first mechanism is based upon a formal and institutional core of knowledge that secures the necessary minimum (guidelines, principles, declarations, management systems). The second refers to comprehensive implicit and explicit knowledge that is shared and created by all university's members (common knowledge on contributions such as energy saving and environmentally-friendly mobility). However, formalized and shared knowledge is necessary but insufficient for complex

[8] http://www.unisolar-lueneburg.de.

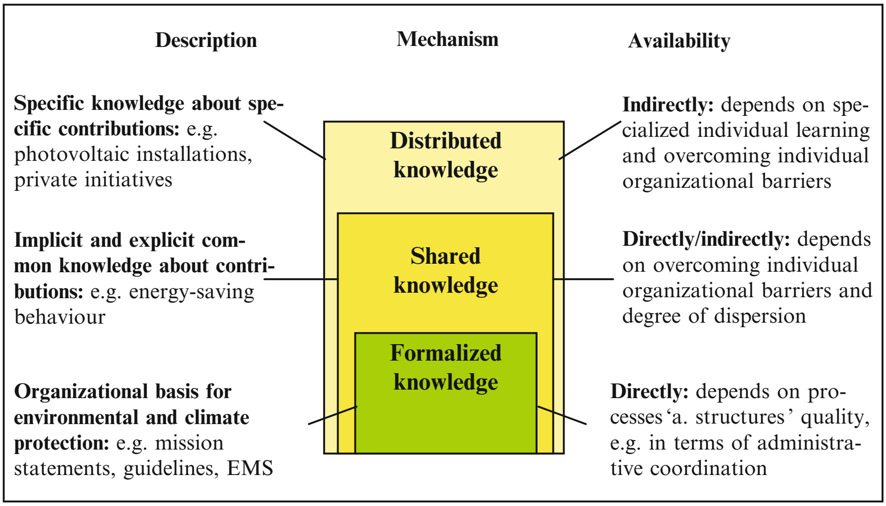

Fig. 4 Mechanisms of organizational learning

sustainability-related activities (such as photovoltaic projects managed by amateurs). If the LULG follows its mission statements it has to continuously trigger individuals' willingness and ability to learn, to create new kinds of knowledge and to contribute to organizational problem-solving.

Becoming a sustainable organization is a challenging task for universities: First, the mission statements of sustainable university and carbon-neutral university stand on a (multi-dimensional) normative foundation. Since norms and values are always subject to sociocultural negotiations on all levels from inter-personal to inter-organizational, the "what to learn?" adds to the "how to learn?". Second, the essential fact that "[universities] have no other brains and senses than those of their members" (Hedberg 1981, p. 6), and that those members belong to structurally two-faced units (loose and coupled) requires demanding processes of reflection about how to improve organizational learning – as a first step, a holistic perspective for the latter question is discussed in this article.

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Chapter 16
Using a Spare Time University for Climate Change Education

Michael H Glantz and Ilan Kelman

Abstract Many educational initiatives, including for higher (post-secondary) education, use various forms of technology. This chapter describes another conceptual as well as practical approach for applying educational technology for delivering higher education knowledge: a Spare Time University (STU). The notion of STU is defined and then applied to climate change education beyond the traditional higher education setting.

The history, creation, implementation, and limitations of STU are noted along with illustrative examples and a more detailed example of using STU to communicate local climate change impacts on rural areas. The result is that STU becomes an information exchanger and stimulator, not just an information disseminator, with users encouraged to become active in spreading STU's information and in developing STU's nuggets and modules.

Keywords Spare time university · ICT for development · Information and communication technologies · Climate change education · Distance learning

Introduction

Article 26 of the Universal Declaration of Human Rights (UN 1948) states "Everyone has the right to education . . . Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit." More recent expressions of this principle are through UNESCO's lead of the global *Education for All* movement which aims "to meet the learning needs of all children, youth and adults by 2015" (see EFA 2007 for goals and details).

The importance of education for addressing environmental concerns, encompassing climate change and other disasters, is reflected in several initiatives. The United Nations Secretariat for the International Strategy for Disaster Reduction labelled its 2006–2007 World Disaster Reduction Campaign as *Disaster risk*

W.L. Filho (ed.), *Universities and Climate Change*,
DOI 10.1007/978-3-642-10751-1_16,

Table 1 Examples of projects on information and communication technology for development

Organization or project	Website
Aptivate	http://www.aptivate.org
Digital opportunity channel	http://www.digitalopportunity.org
Institute of Development Studies (IDS) strategic learning initiative	http://www.ids.ac.uk/go/sli
First mile solutions	http://www.firstmilesolutions.com
SustainIT	http://www.sustainit.org
Technologies for conservation & development (t4cd)	http://www.t4cd.org

reduction begins at school and that incorporated climate change elements. Wisner (2006) reviewed the role of education and knowledge in disaster risk reduction, which incorporated climate change and which included case studies of using the Internet. He noted that a constraint frequently faced is the imbalance between the rich and the poor, countries and individuals, in access to and availability of information and communication technologies.

Various mechanisms exist for further creating, developing, and enhancing individual and institutional climate change education initiatives by using appropriate technology. Some initiatives, noted in Table 1, are designed for overcoming technological imbalances, such as closing the gap known as the "digital divide" between rich and poor countries and people, and for using technology to disseminate information more widely. These projects assist in addressing the human right of education, especially access to higher (post-secondary) education. Although none of these projects are focused on climate change, their mandates shadow areas related to climate change and their technologies and techniques could easily be applied to climate change education.

Here, another approach is described for using educational technology and techniques for developing and enhancing climate change education which can be geared towards the post-secondary level: a Spare Time University (STU). STU does not seek to supplant or dominate other approaches. Instead, it complements them by disseminating information through technology on the terms defined by the users' own needs, time available, geographic location, and technology. The goal of STU is to empower anyone to have access to knowledge and information without having any specific level of formal education (see also Glantz 2007). The next section details the notion by describing the historical development, implementation, and limitations of STU. Section 3 illustrates the use of STU for climate change education. Section 4 summarizes the material.

Spare Time University (STU)

STU provides an accessible pathway to educate and empower through using a range of new technologies which will share knowledge about challenges of concern and ways of addressing those concerns. In this case, climate change education is highlighted, especially what individuals and communities could do to address climate change. The audience includes anyone who wishes to make use of the information – for example, about climate, water, weather, saving energy, and using less fossil fuels – from a farmer in rural America to a business person in Phnom Penh to a scientist in Bangui to poor children in a favela in Rio de Janeiro.

An expression often heard from water resource managers is that “water flows uphill to money”. That means that those with funds can acquire, whenever they choose to do so, water in the quality and quantity that they desire. The same sentiment can be applied to education: “education flows uphill to money”. Those with disposable income can afford to put it towards educating themselves and their families, while those without extra income are forced to treat education as a real-life luxury rather than as a theoretical human right.

Even people with enough money for education often feel that they are too busy to take courses in a formal classroom setting, either at their workplace or on their own free time. Poorer people are often either too busy trying to put food on their table or they do not have the funds to go to traditional places of learning, such as schools, universities, libraries, and community centres. Their reading and writing skills may also be at relatively low levels, even though they have strong verbal communication skills.

Instead of people having to go to designated places to learn, the learning environment can go to them. The information must be free and it must use media to which people have access without the added cost of acquiring something new. One of the tenets must be “open access”, including for scientific information. The debate on open access to science (e.g. see Butler 2003; DC Principles 2004; Giles 2007) relates to this principle. The advantage of STU is that it provides known, reliable, and useable scientific and action-related knowledge to provide an opportunity for anyone who takes advantage of it to acquire a basic understanding of climate change and how to act to deal with this challenge.

Many people have access to radio, mobile phones, and newspapers, even when they are classified as “poor” or as being at the status of “subsistence living”. In a few cases, free Internet access at community centres or libraries is helping to close the Internet gap for less affluent households. In other cases, a family-owned radio is the focus for each evening’s entertainment and could become the focus for each evening’s family education.

Using existing technology, including responding to the limited access and equipment of the least affluent, and adjusting as technology changes, means that knowledge can be delivered to each person in the format they desire and, most importantly, at the time they desire. As information and communication technologies advance, the price of existing technologies will fall, making them increasingly accessible to those who are less affluent.

STU History

An historical approach to implementing the notion of STU was *The Penny Magazine* in England in the 19th century, the first edition of which appeared on 31 March 1832. Published every Saturday and aimed at working class people in England, the

Society for the Diffusion of Useful Knowledge used the magazine as one of its approaches for liberal reform. The ethos was to cater to the "very great number of persons who can spare a half an hour reading a newspaper" (Reading for All 1832, p. 1). Given the various methods of land- and water-based transportation available to reach its readers, *The Penny Magazine* would be put "within every one's reach in the farthest part of the kingdom, as certainly as if he lived in London, and without any additional cost" (Society for the Diffusion of Useful Knowledge 1832, p. 1). The principle was that *The Penny Magazine* would provide open access to anyone interested in acquiring knowledge by using existing forms of media, namely the printed page, disseminated through already-available transportation modes.

A century later, a Spare Time University was developed by Mao Tse-Tung in China during the revolutionary 1930s. For the most part, the initial stages of China's STUs were designed to raise literacy levels in the country and to prepare students for entering the workforce in industry and agriculture. Almost a decade after the Communists' 1949 victory in China, policies to establish STUs became law in 1958 (Abe 1961). The STU approach was also designed to close the gap between students going to university full-time to earn advanced degrees and labourers in fields and factories who had neither the time nor the level of education required to succeed in a formal university setting. It was an attempt to increase educational equality across society by raising the literacy level of workers so that they could become a part of the country's development process.

Despite some abuse at times by bureaucrats seeking to enhance their qualifications (Ma 1990), China considers its STU programme to be successful. The form and function of STUs across China have changed over the decades, including the founding and development of Radio and Television Universities, a Self-Study University, and a Seniors' University (McCormick 1986; Boshier et al 2006). Given their success and popularity, some Chinese universities have begun to absorb STU structures into their formal programmes.

Elsewhere, the STU concept was also being considered and implemented. In the UK, "the Open University was founded on the belief that communications technology could bring high-quality degree-level learning to people who had not had the opportunity to attend campus universities" and "was the world's first successful distance teaching university" (http://www.open.ac.uk). *University Without Walls* programmes across the United States provide flexible degree programs for working students. For the Netherlands, de Goede and Hoksbergen (1978, pp. 443–444) wrote "those who require education should be able to combine studying and working . . . it is necessary to take immediate steps to provide for working students by setting up a special university for them". They suggested that the name could be "Open, Evening, Workman's, Spare Time University" (p. 444). The impressive and useful work of all these institutions can continue to be expanded and enhanced – and applied specifically to climate change education – by using the latest educational technology.

Creating an STU

The education received via STU does not have to meet a work goal, a degree, or a certificate fulfilment. It can be done to increase one's knowledge on topics of personal or professional interest, as a form of a personal university outside the traditional higher education setting and beyond the traditional definition of "university". The basis of STU is information delivery by any technological means so that it matches users' needs in rural as well as urban areas, and in affluent as well as non-affluent areas. The building blocks are the packaging of information in different ways, depending on the technology and information needs.

Smaller packages could be brief "nuggets" of useable information: a few paragraphs, written or spoken, with basic facts or action items which could be sent as mobile phone text messages, voice mail, or as text-only email. Such nuggets could serve to stimulate thinking among the STU participants. Larger packages of information could be multimedia, interactive lectures, seminars, or podcasts accessible online or viewed with a DVD player, on a television, or on a computer. These larger packages might be consumed by people in their own homes, viewed in Internet cafés, or displayed in a room of a community centre or library for anyone to view. Interactive, live seminars and discussions via video-conferencing facilities could be used too, as implemented by the University of Hawaii's PEACESAT (Pan-Pacific Education and Communication Experiments by Satellite) programme (http://www.peacesat.hawaii.edu/01HOME/Welcome.htm).

A range of intermediate packages would be needed as well. Audio-only programmes could be fed to radios, satellite radios, or MP3 audio players for listening either in people's homes, while they work in the fields, while they fish, or with communal technology at a community centre or library. Someone might summarize a lengthy podcast or a DVD/MP4 video player seminar for distribution to their community in printed copy in their local language and vernacular.

The mode of delivery, however, becomes increasingly challenging as users of STU become more remote and poorer. Many locations might need to request modes of delivery which could require STU personnel to dedicate themselves to a particular location. For example, the British island of Tristan da Cunha in the South Atlantic Ocean, the remotest inhabited island in the world, has neither an airport nor a large harbour. The population of approximately 300 could be asked whether STU materials should come to them via the one Internet connection on the island, via satellite, or via CDs, DVDs, pre-loaded MP3 and MP4 players, or printed material delivered by one of the handful of ships which call on the island each year.

The emerging "wireless wars" in information technology and the competition among wireless information delivery systems – mobile phone, satellite radio, wireless computer, personal digital assistant, MP3 audio player, and MP4 video player – would favour the availability of STU to serving such remote locations. The prices for new and used devices are dropping markedly for these forms of communication, as demand for them expands. Smaller populations, such as those on

Tristan da Cunha, can reap the rewards of lowered prices generated by the demand from larger populations, making the entry point to STU easier.

The information packages disseminated by STU would be as broad and as deep as desired by the various users and would be determined to some extent by the constraints of the various technologies and techniques. Nuggets of knowledge sent to mobile phones would, when compiled and strung together, provide a significant amount of basic knowledge on a chosen topic of interest, such as increasing the natural ventilation of common dwelling types to cope with higher humidity and more frequent heatwaves, an expected impact of climate change in many locales. Audio-visual programmes disseminated via broadband Internet or MP4 players could be lengthier, forming a module to provide both brief as well as in-depth chapters of information. Topics could be as specific as "implementing non-structural flood risk reduction for residential properties affected by increased runoff or worse storm surges" (see, for example, Etkin 1999; Fordham 1999) or as general as a broad overview of "how to develop community teams for incorporating energy reduction measures based on those for reducing disaster vulnerability" (see, for example, Ogawa et al 2005; Simpson 2001).

A series of modules might comprise the equivalent of a semester course at a university on a specific aspect of climate change. A series of courses could lead to a qualification for a certificate of completion. While STU's basis is an informal educational process without a formal obligation to commit time or money, which also assists in making the educational process less threatening, as a user's learning broadens and as more time is invested, there might be a desire for formal acknowledgement of the knowledge gained. Such recognition or qualification could range from a simple certificate of educational achievement to contributions towards a formal higher education degree, especially by distance learning.

The nuggets and modules for STU would be produced by people knowledgeable about the topics of concern and able to communicate that knowledge in user-friendly language and format. Climate change related science, impacts, and actions would be explained in a vocabulary suitable for a variety of audiences. People could be trained and compensated to provide information – in written, audio, and visual forms – in their local dialects.

STU is a knowledge conduit for people who wish to learn useable information about science, policy, and action – and then to apply it to climate change – as well potentially other disaster, environment, and sustainability topics. The "faculty" and "students" include scientists from all fields, policy and decision-makers, and practitioners (for example, farmers, fishers, horticulturists, and health workers) who wish to learn more about their speciality or to share their knowledge with others – and to learn about topics outside their speciality. For example, meteorologists and climatologists might wish to learn more about the social, political, and cultural settings in which their physical science research findings are to be embedded. Meanwhile, behavioural scientists working on responses to weather and flood warnings would benefit from knowing more about the physical parameters of the storm which could affect the population about which they are concerned.

Traditional, local knowledge should also be shared with scientists to ensure that the science does not miss important facts and understandings (e.g. Dekens 2007).

Given the various audiences with diverse amounts of time and resources available for learning, any medium available that provides flexibility to the participant would be used by STU. Lack of access to electricity is not necessarily an impediment to wireless technologies, considering the possibilities for small-scale solar, wind, water, and hand-powered rechargeable batteries to be used in radios, players, and other communications gadgets.

Printed products are also part of STU, especially for those with little access to wireless or other communications technologies, but telephone and Internet landlines serve too. STU material would be available for all technologies and all speeds of transmission. Those with good Internet access could make use of high-bandwidth multimedia presentations. Those with only dial-up or satellite-phone access might stay with text-only products or make use of techniques and technologies designed to access the Internet with low-bandwidth connections (e.g. see Table 1, especially Aptivate http://www.aptivate.org).

Face-to-face contact should not be lost. Those who wish to engage in volunteer teaching could access STU material and then pass it on to others in day-to-day conversations with neighbours and friends, or by holding community gatherings. Face-to-face contact also serves for sharing printed material and electronic files where possible.

STU would take advantage of "teachable moments". This notion refers to the constant stream of current events which gain prominence through 24-hour all-news channels and the Internet. Climate-related events are especially poignant and are often attributed to climate change, whether or not that label is scientifically accurate. Following Hurricane Katrina in 2005 which struck the US Gulf Coast, all forms of media were besieged by reports and information, from first-hand eyewitness accounts and in-depth analyses to rumours. This non-stop coverage was available around the world, at times leading to extensive repetition due to a dearth of new information. Such situations are ripe for "teachable moments" to be blended with the coverage (Glantz 2008), involving nuggets of relevant information such as practical science on how Hurricane Katrina was and was not potentially affected by climate change, preventive measures for both climate change and hurricanes, and likely long-term impacts of both climate change and Hurricane Katrina.

This flurry of media interest in a specific event becomes an opportunity to provide STU teaching material for application to local needs. For example, after Hurricane Katrina, abundant information on hurricanes, hurricane damage, and warning and evacuation systems became available. That abundance of information could easily have been "mined" for STU's educational nuggets and modules, making it location-specific; for example, explaining the difference in threats from a hurricane's storm surge or its rainfall-induced flooding when on a low-lying stretch of open compared to being in a steep ravine.

One consequence is that STU can contribute to demystifying climate change science while making that science accessible to, as well as useable by, people who are not usually exposed to science. The science is further used to inform people about impacts, policies, and actions. STU provides a "back-door" approach to improving science literacy and awareness, especially in tackling human activities, from local to global levels, which lead to climate change and its consequences. Overall, STU empowers people with useable knowledge about the climate change issues that they might face.

Limitations

Two major concerns of the STU approach are (1) the accessibility for users of technology due to the initial cost and infrastructure which limits access and (2) the perception of lack of spare time required to participate in the learning process, including in STU. Rather than making people more equal – for example, from rural to urban and from rich to poor – accessibility and time could widen existing gaps. For instance, technological infrastructure is usually much better in urban areas than in rural areas, so urban dwellers might gain more advantages from STU than rural dwellers. Meanwhile, whether it is with a mobile phone, on a laptop, or at an Internet café, accessing STU information requires a modicum commitment of time and money. Both tend to be more affordable for rich people than for poor people.

The structure of STU overcomes these issues to some extent, but cannot do so entirely. By providing information in a format and manner geared towards the user, the vast majority of people will have some form of access. Many poor, rural farmers and urban dwellers already rely on their mobile phones. They could use STU through text messaging and voice mail. Many poor, urban families have radios, and could listen to STU programmes. In addition, the information received in a rural area might be of more immediate value and significance to the user than that received in an urban area, where various competing sources of information are much more readily available. Cheap audio players could be provided by governments or development organizations to those who cannot afford to secure and maintain them with their own resources.

A non-profit organisation called One Laptop per Child (http://www.laptop.org) seeks, with the countries' governments, "to create educational opportunities for the world's poorest children by providing each child with a rugged, low-cost, low-power, connected laptop with content and software designed for collaborative, joyful, self-empowered learning". Through each child with a laptop, extended families and neighbours would be exposed to the laptop's power to educate with STU's modules. While maintenance costs, replacement parts, electricity access, and spare time to learn could still drive a wedge into equality, this endeavour is one of the myriad of projects which seeks to overcome constraints on accessibility and time availability. In other words, it is contributing to closing the "digital divide" as one of many efforts, even if it cannot solve the entire problem on its own.

Many of the barriers to education mentioned earlier, especially in less affluent areas, still exist with STU. Yet STU can help to diminish, with government and international agency buy-in, those barriers, while forging pathways to further break down the obstacles to the human right to education.

To improve accessibility, STU would also be provided in formats which overcome individuals' other constraints, including hearing, vision, or mobility challenges. Audio-only programs would serve people with vision challenges. By bringing information to people wherever they are on their terms, mobility-limited people are directly served. In addition, making use of the latest technology means hardware as well as software, such as a voice-activated or hands-free mobile phone.

STU's structure is matched to whichever technology is or can be made available for each local and individual context. With the educational material being free to the user, it is ultimately the decision of individuals, families, and communities to use it.

Two other limitations apply to STU as well as to most other universities and educational initiatives. First, ensuring quality control of the information disseminated. Care must be taken that STU's informal nature does not lead to poor-quality or inaccurate material. A review process for STU material could be used to maintain quality, as long as concerns about such processes (e.g. Wennerås and Wold 1997; Johnston and Pattie 2004) would not inhibit STU. Second, many climate change issues are politically sensitive. As a result, the vocabulary used and connotations implied, especially when translating into local languages, will require careful review to ensure correctness without making political or cultural gaffes which might undermine STU's credibility.

STU for Climate Change Education

Climate change will affect a subsistence farmer's or fisher's decisions, but it might not be clear from their experience and local knowledge what they should be considering and how they might need to adjust their behaviour. For example, the presence, timing, and magnitude of El Niño and La Niña events influence rainfall in countries such as Peru, Fiji, and Mozambique. Fisheries are also affected along South America's west coast and across the Pacific (Glantz 2001). Yet forecasts have uncertainties in terms of characterizing the onset, severity, and timing of decay of El Niño and La Niña events and past records might not be suitable for understanding how climate change will affect El Niño and La Niña in the future. Farmers and fishers could be provided with timely updates to forecasts, observations, and long-term trends in order to make adjustments to their activities for each week, each season, and each decade. Updates could be as brief as a few sentences, sent as text messages or text-only email, or as lengthy as a distribution of possibilities with the likelihood of each possibility occurring, sent out over radio or via a long graphics-based email.

Community teams for reducing vulnerability to disasters were mentioned earlier with the suggestion of incorporating energy reduction measures into the teams' activities. STU could provide a baseline of information for using the community

Table 2 Examples of short, simple messages for climate change for an affluent audience

Scenario	Do message	Don't message
When going out...	Remember to turn out the lights	But don't reduce your property's security
When hotter than normal...	Drink plenty of water...	Don't overexert yourself
If the road is flooded...	Turn around, don't drown (http://tadd.weather.gov)	Don't drive through the water

teams to not only respond to climate change consequences, such as worse floods, but also to prevent the challenges arising in the first place, as linked to other environmental and sustainability measures – such as reducing electricity, fossil fuel, and water use. That could be as short as simple messages to teach and remind (Table 2) or as complicated as modules covering designing one's own zero-net-energy dwelling or re-using waste to avoid the need to transport it to landfills, thereby saving fossil fuels. The messages must be contextualized and appropriate for the audience. Table 2, for example, applies to an affluent audience.

Other illustrative examples are modules covering the theory and practice of constructing a small-scale wind turbine, emissions trading schemes, how climate change could affect people with disabilities, using passive solar energy, or finding water during dry spells. More general knowledge topics range from implementing community-driven approaches based on traditional knowledge (Gaillard 2007; Mercer et al 2007) to distilling the Inter-governmental Panel on Climate Change's latest report (IPCC 2007) for the local context. Mountain tourist areas might use flash flood and rainfall-induced landslide modules while Caribbean islands might exchange hurricane damage prevention lessons with typhoon-prone Pacific islands to share their experiences (e.g. SOPAC 2005).

Case Study: Local Climate Change Impacts on Rural Areas

In December 2006, one of the authors (MHG) met with elders in a rural settlement near Nairobi, Kenya. As a result of a European Union project, the settlement had recently received a water supply piped into individual homes. In considering the reliability of the new water supply, the elders asked several questions about climate change and described what they believed to be changes in local climate, water, and weather conditions that they had observed over previous decades. This experience exemplified the value of meeting the information needs of rural people regarding their local weather, climate, and water issues – as well as the value of their knowledge and experiences which could be used to inform others locally and in other locations.

During the meeting with the elders, several of them had their mobile phones in front of them on the table. Occasionally, there was a "pinging" sound, indicating that a text message had been received. These text messages might have been personal comments, advertisements, or weather warnings – or a combination. The same system could be used through STU to provide climate change nuggets via text messages or voicemail which would answer the questions that the elders were asking.

This situation was people in need of information owning a technological mechanism by which they received information. A pathway is available for useable, timely, scientific material to reach people in this rural community – exactly what STU promotes. This idea was discussed with the elders who were responsive to it.

This experience also revealed another possible dimension of STU: the information flow is not unidirectional. If the elders received one text message a day regarding possible water-related problems linked to climate change, such as increased probability of summer droughts, they could forward it via mobile phone or read it out to family and friends. Their family and friends could respond with STU text messages that they have been receiving on water-related problems not directly linked to climate change, such as how to try to save someone from drowning without putting others at risk.

STU becomes an information exchanger and stimulator, not just an information disseminator, enabling users to become active participants in spreading STU's educational information and in developing STU's nuggets, modules, and packages. The elders could further respond to text messages and voicemail by rating each one's usability for the local context and, as they did during the discussions, by describing their own experiences, advice, and knowledge. Their nuggets could be sent to STU users nearby or adapted as case studies for STU users everywhere. Because the elders already have mobile phones, that becomes the technological conduit for information development and exchange on climate change – or any other subjects of interest.

Conclusions

STU is an educational vehicle that will complement as well as overlap already-existing structures and initiatives for distance, virtual, and web-based education with climate change being a useful starting point or pilot project. It deliberately invokes the concept of higher education while equally deliberately going beyond the usual concepts of and settings for higher education.

For the vast majority of the world's population, particularly in rural areas and in less affluent communities, communication over long distances still remains a significant challenge. These locations tend to be the most in need of climate change information and advice – and beyond climate change to other disasters and to other environmental, development, and sustainability information and services. The principles and practices of applying educational technology to STU should be used to further create, develop, and enhance capacity in all areas of living and livelihoods.

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Chapter 17
Embracing the Future: The Ball State University Geothermal Project

James W. Lowe, Robert J. Koester, and Philip J. Sachtleben

Abstract Ball State University will convert its campus from a coal-fired and natural gas-fired district heating system to a closed loop heat pump chiller district heating and cooling system serviced by more than 4,100 geothermal boreholes. It will be largest district ground source geothermal system in the United States. On May 29, 2009, an article in the The New York Times called Ball State "a pioneering university" for undertaking the initiative. The installation will include an integral programme of research designed to inform the industry – especially the owners of 65,000 other district-heated buildings in the U.S. – how to significantly reduce the "first costs" and risks associated with intensive borehole drilling, piping, and looping. These issues are cited in a 2008 Department of Energy (DOE)-sponsored study as a major impediment to the more widespread adoption of geothermal systems. The planned research will incorporate 2D resistivity programming, geological surveys of the impact of high-density boreholes on ground temperature, assessment of the role of soil and water pH, evaluation of the influence of variable system water flow, analysis of hydrological data, and verification of the claims made by new geoexchange pipe manufacturers for dramatically increased thermal transfer (40–50%) and the concomitant reduction in the number of required expensive boreholes (20–35%) to service a load.

Keywords Campus · Climate-neutral · Geothermal energy · Sustainability

Background

In 2009, we find history repeating itself. The Ball brothers (founders of the Ball Corporation, the renowned manufacturer of Ball canning jars) came to Muncie, Indiana, on the promise of reducing costs for their glass production business by

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pulling from the ground “free” energy from the East Central Indiana natural gas deposits. Now, Ball State University, their founding namesake, will begin to save a net $2 million annually in avoided fuel costs (at today’s prices) by pulling from the ground a different form of “free” energy – the geothermal energy stored (and storable) – in the earth’s mantle.

In February 2009, the Ball State University Board of Trustees approved recommendations from the Facility, Planning, and Management staff to replace the existing coal-fired boilers used for campus district heating with a ground-integrated heat pump technology. This geothermal district system will provide heating and cooling for the entire campus and will present opportunities for real-time, field-based research as the project comes online.

The term “geothermal” is not new but, in fact, a rubric under which *many* differing technological applications find their home. In its purest form, the term “geothermal” applies to energy extraction for heating purposes using hot rock sources in various locales throughout the world in which steam extraction from the ground is used for space heating and water heating – or in select instances, for driving turbines that generate electricity. However, the term “geothermal” has been applied also to water extraction; wherein groundwater is used as an energy capacitor in a heat pump exchange providing either cooling or heating at a single-building, residential or commercial scale. Often with single source extraction, the groundwater is pumped from the earth’s mantle and, after the energy exchange, is then rejected to a surface feature such as a stream or pond. By contrast, injection wells can be used to return the groundwater to its original location. However, such open-loop technology is problematic: water extraction can deplete ground water supply or returning that water can provide a vector for potential contamination of the ground water aquifer.

To counter these complications, it is possible to use closed-loop water re-circulating technology; heat exchangers are sunk into the ground and by way of temperature differential, wherein heat energy flows from hot to cold, only the heat energy is removed from, or injected into, the ground. A residual factor at times can be that an improperly designed exchange field (borehole placement and count) may result in an excessive build-up or reduction of ground temperature. But if the borehole field is properly designed, the below-frost ground temperature will not change from a nominal 55° Fahrenheit. Some closed system installations make use of a horizontal looping of pipe at moderate depth in a sizable area of land; similarly a horizontal looping of pipe can be placed in a standing pond or flowing river, each of which act as a capacitor from which thermal energy can be removed, and into which it can be placed. These closed systems often include a circulating glycol and water mix to ensure that the system will not freeze; this can be problematic as this offers the potential for chemical contamination of the groundwater should a leak occur.

Certainly the open-loop and closed-loop systems are well established in the market and yet there simply is no precedent for use of geothermal technologies in a large-scale district heating and cooling installation.

Context

With the growing international concern for global warming and the need to reduce and ultimately eliminate worldwide the carbon dioxide equivalent (CO_2e) loading of the atmosphere, there has been a developing interest in the geothermal technology as a means to avoid the combustion of a fossil fuel and the avoidance of CO_2e production. Geothermal systems, of course, are powered by electricity which itself may come from a fossil fuel-based generating facility.

But given these concerns for climate change and the role that universities can play in shepherding new visions for the future, a number of initiatives within the United States have taken hold including the creation of the American College and University Presidents Climate Commitment (ACUPCC) and the Sustainability Tracking Assessment and Rating System (STARS) both supported by the Association for the Advancement of Sustainability in Higher Education (AASHE). These reflect a growing desire on the part of universities to serve as examples of best practice and to educate their many constituents not only in the use of conservation practices but also new technologies that can reduce the institutional contribution to global warming. The national and international stage is being set to support and reward innovation.

Indiana itself has a long history of innovation, once vying to be the auto capital of the nation by hosting nearly 200 automobile manufacturers over the years. Now Indiana is applying that entrepreneurial spirit to the field of alternative energy. Recent headlines have publicized the growth of wind farms within Indiana, the migration of green companies to Indiana, and the origination of green technologies by Indiana entrepreneurs, including electric car initiatives, solar power advances, and more. And now Ball State University is adding to those headlines by building the largest district-scale heating and cooling groundwater geothermal heat pump technology installation in the country.

Introduction

Ball State University, which has a long-standing commitment to sustainability, is playing a key role in this alternative energy renaissance. The university has found itself uniquely positioned in this context: (1) our president was one of the twelve originating signatories to the American College and University Presidents Climate Commitment: (2) our university needed to replace its existing fossil-based coal-fired chain-bed boilers (which date to the 1940s); and (3) our university has been growing its engagement with principles and practices of sustainability as a triple-bottom line metric – an evaluation of social, economic, *and* environmental cost/benefit.

In 2008, our facilities management team began looking at replacing our existing coal-fired boilers with a more efficient conversion technology using Circulating Fluidized Bed Steam Boiler (CFB) and filtration devices to delimit production of the CO_2e gases and to increase the efficiency of the energy extraction from the source coal. Because of a coincidence of factors including a limited current construction market for installing this technology, and the commitment of the institution to the employment of best practices, the university turned to the National Renewable Energy Lab and Oak Ridge National Laboratories for consultation on whether in fact ground source geothermal could begin to meet the needs of a district-scale heating and cooling system; servicing some 47 buildings.

We identified consultants and designers; with their assistance we developed a series of design scenarios for scaling-up the geothermal technology to support a district heating and cooling system. To be sure of the capabilities of the design schemes, the university then undertook a proof-of-concept evaluation and a field test of technical application to determine the feasibility and cost-effectiveness of the idea. With the success of the proof-of-concept and field testing, the confidence level took hold for moving forward with what we have discovered is the largest district-scale heating and cooling groundwater geothermal heat pump technology installation in the United States.

With the design and feasibility work completed, the university secured approval from state agencies to repurpose to the geothermal installation some $40 million that had been appropriated initially for the high-efficiency coal-fired district heating boiler replacement; with the approval of the board of trustees to commit to the longer-term build-out of this installation – using available funds to capitalize the first couple modules of installation and the use of savings from avoided fuel costs to underwrite subsequent stages of completion for the project. Since the adoption of the plan, the university continues to pursue federal funding to cover the marginal difference between the appropriation and the projected full cost of build-out.

Detailed Discussion

Initial Consideration of Geothermal; Finding Large-Scale Geothermal Designers/Engineers

As the university could not continue to pursue its CFB solution for financial reasons, it began to consider an alternative solution that would incorporate new geothermal heat pump technology. The university received assistance from the office of US Senator Richard Lugar to arrange a teleconference with scientists and engineers from the National Renewable Energy Laboratory (NREL) and the Oak Ridge National Laboratory. During that teleconference, the NREL and Oak Ridge personnel identified the top geothermal experts in the United States. Ball State proceeded to engage several of those experts in discussions about the challenges associated with a project whose size would make it the largest of its kind. Two of the experts are now under contract to design the geothermal system. Lugar, who spoke during the groundbreaking ceremony, called it “a bold endeavor” with significant consequences for the energy future of Indiana and the nation.

As the university focused on the geothermal option, it contacted a variety of designers. One of the initial realizations was that this project would be unprecedented in size. There are other universities that have installed geothermal systems to serve a handful of buildings. However, none is designed to heat and cool 5.5 million square feet of area in 47 major buildings spread across a 660-acre campus.

To be prepared, we gathered ahead of the initial meeting with the designers a tabulation of steam-generating capabilities, boilers capacity, chilled water production capabilities, and chillers capacity. We also tabulated consumption history for both steam and chilled water. This information provided the basis for determining the load profiles for both heating and cooling. This also helped to determine whether the campus had a heating- or cooling-dominant need; with this information in hand and by documenting the specific equipment capacities within each of the 47 buildings, we enabled the designers to determine how many boreholes, and what capacity of heat pump chillers would be required.

We found that we had 14,000 tons of connected chilling load. This led to a ballpark calculation that we might need as many as 7,000 boreholes. As unitary geothermal systems were reputed to be the most efficient, our initial desire was to find a way to provide geoexchange capability within close proximity of each building. This proved to be impossible; the nearness of residential sectors of the city of Muncie and the concentration on campus of many of the buildings in “quads” yield insufficient available ground space for boreholes. And of course, using a lake or river as the geoexchange could not be considered because there is no major body of water on or adjacent to campus.

We could identify a reasonable amount of open ground adjacent to about one third of the campus buildings. In addition, the campus has several large open spaces used for parking lots, sports, and recreational activities. The eureka moment for this project followed a set of discussions with engineers who thought it might be possible to use these remote open spaces as borehole fields that could provide the geoexchange necessary to service two or more “district energy stations” located in geographically separated areas of campus. The district energy stations would be connected by a large hot water pipe that would form a loop around campus. Each building would then be connected to the hot water loop.

Considerations

According to the experts at both the Oak Ridge National Laboratory and the National Renewable Energy Laboratory as well as those involved in our design, the use of heat pump chillers to produce chilled and hot water connected to a district heating and cooling distribution system has never been used on the scale (47 major buildings over 660 acres) that we propose. This is due to the only recent availability of the larger scale efficient heat pump chilling equipment with lower operating costs. In addition, the prospect that air quality requirements will be strengthened in the United States through a federally mandated carbon tax or cap and trade carbon accounting system added to our valuation of the benefits a geothermal system would provide. Given the fact that geothermal systems for individual buildings have been in place for many years and are considered a mature technology, our expectation is that while the first costs of such systems continue to be higher, the reduced operating costs should only improve.

Financial Calculations

Final cost figures will not be known until the various parts of the project, including borehole drilling, installation of piping, heat pump chillers and pumps, and air handling changeovers for some buildings, etc., can be put to bid; nonetheless, it appears that the total price tag will be in the range of $70 million. The university currently has available $41.8 million from the proceeds of a bond issue, and the plan is to proceed in phases. The elements outlined above, using existing funding over the next several years, would result in the decommissioning of two boilers in the first phase. For the remaining components of the project, additional funds will be sought from sources involving federal alternative energy accounts, the federal stimulus package for green projects, private foundations, and operational savings. Since this project is now underway, it is the university's belief this project could be well positioned to apply for assistance in line with the expressed goals of the Congress as follows:

1. The project will greatly improve the heating and cooling energy efficiency on campus.
2. The initial borehole drilling and pipe installation, which represent about 40% of the overall project cost, is "shovel ready" and will put people to work very quickly.
3. In contrast to the CFB system, every component of the geothermal technology is made in America.

Advantages of the proposed project to the university include the following:

- Replaces obsolete coal-fired boilers (three natural gas boilers will remain in place as backups)
- Buffers against future fuel cost volatility
- Reduces long-term operating costs

- Reduces approximately 50% of the campus carbon footprint
- Eliminates other air pollutants
- Qualifies for Department of Energy funding
- Comprises American made components
- Creates new jobs immediately in the engineering, construction, and manufacturing sectors.

The Academic/Facility Research Opportunity

In scheming the system for our campus, it was necessary to consider the modulation of the construction for a number of reasons: (1) to fit the technology into the footprint of the campus; (2) to link the piping systems to the existing district heating and cooling network; (3) to scale and modulate the installation to match that of the cycles of budgeting and capital investment; and (4) to introduce field-based research on alternative detailed technical installations that could offer the promise of reducing first-cost of installation – the traditional barrier to a broader use of this technology.

One of the more interesting aspects of this enterprise is the need and opportunity to pull together faculty and engineering professionals of differing expertise. The research options include the evaluation of: (1) the use of differing types of piping for looping within the boreholes, the horizontal ground looping and the placement of distribution piping on the campus; (2) new material mixes in the piping to enhance heat exchange; (3) new geometries of pipe profile to enhance heat exchange; (4) the rates of flow needed to balance energy exchange between the "sourcing" and "sinking" of energy using the capacitor effect of the geologic substrates of the campus; (5) the geologic substrate and its impact on the drilling of the boreholes; (6) the expected rate of extraction/injection of energy; (7) the influence of that on the spacing of the boreholes; (8) the patterning and looping of sets of boreholes in groups as "pods"; and (9) the interface of these energy exchange fields with the heat pumps that will drive the distribution of heating and cooling campus-wide.

One of the more appealing aspects of the heat pump chiller technology is its ability to generate both hot water at 150° and chilled water at 45° simultaneously. This technology can first transfer energy from the chilled water return loop to the hot water loop. When sufficient energy is not available, the heat pump chiller draws energy from the borehole loops. By looping buildings together in a district arrangement so as to exchange energy building to building as a first-order of energy flow management, this energy can be reused and not wasted. Once such exchanges are achieved, the earth will be called upon as a source or sink for the energy difference.

From a first-blush economic point of view the $65–70 million price tag for this district system spread over a 5–10 year period of installation may seem to have a low-order return-on-investment. However, it is important to acknowledge that the cost of installation of this system (as a net return-on-investment) must be measured as the marginal difference between the initial plan for capital expenditure (a more efficient CFB coal-fired plant) and the (highly efficient, modulated, and management-effective) ground source heat pump system. Given the likely savings of some $2 million per year (net) in avoided fuel costs – which accounts for the added cost for electricity from the Midwestern electrical grid – the projected yield is a significant return-on-investment in a simple straight line comparison. When leveraged to include the full range of impact, that ROI is even better.

One of the tributary impacts of this enterprise is the opportunity to stage the institution within the emerging carbon market enabling us to shift our focus to our electrical grid sourcing of energy and the potential for supporting the growth of a green economy – specifically green energy sources – feeding into the grid.

Within Indiana in the last several years we have experienced a burgeoning development of wind farm installations for alternative energy supply into the grid; the potential long-term for the university is to source all of its electrical power from such green supply.

Conclusion

Although the future never can be fully known, Ball State University has positioned itself strategically to respond to the complexities of the times. We are maximizing the use of a proven technology at a new scale of application that offers a sophisticated means for modulating energy management; we will be able to network buildings one-to-another to trim and finesse the balance of energy flows campus-wide before drawing on the earth as a source or sink of thermal resource.

The project will impact the local economy – offering immediate job opportunities and the chance for repurposed job training for water well-drillers who can shift their expertise to that of borehole drilling, looping, and routing. Over the longer term, through purchases of green power, the project will contribute regionally to the growth of the national green economy, supporting the regional green energy industries that will feed the electrical grid.

This, coupled with the continuing opportunities for hands-on applied research, offers an additional measure of return-on-investment, one that is not as readily monetized but certainly will accrue to the benefit of the university, the state, and the regional economy.

Most importantly, as a signatory to the American College and University Presidents Climate Commitment, Ball State University through its geothermal project will move substantially toward meeting the obligation of becoming a climate neutral campus.

Proof of Concept: Heat Pump Chillers with Geothermal Storage
Produced for Ball State University

Prepared by MEP Associates, LLC and Kirk T. Mescher, PE of CM Engineering

MEP Project No. B20.08. 01
January 28, 2009
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Introduction

In today's economic climate of high and rising fuel costs, many managers of large 24-hour facilities do well to examine new and creative ways to trim energy bills. One smart option is to examine the potential of a source that is already available, repurposing heat that is ordinarily discarded by the HVAC system's condenser.

By utilizing heat pump chillers with geothermal storage instead of ordinary chillers, the temperature of this formerly waste heat can be increased until it is suitable for a wide variety of heating applications, and utilized when it is needed.

This report provides a proof of concept for heat pump chillers with geothermal storage. It will allow Ball State University to have an introductory understanding of this type of system, as well as some preliminary operational costs developed by Kirk Mescher of CM Engineering, in order for university personnel to evaluate the compatibility of this technology with their campus.

The Concept

Heat Pump Chillers

A compound centrifugal chiller is a special kind of centrifugal chiller that utilizes a combination of two (i.e. compound) compressors, instead of just one, and a component called an intercooler. The additional compressor and the intercooler allow the compound centrifugal chiller to produce condenser water at a much higher temperature than was previously possible with a standard centrifugal chiller. No longer fit only for rejection out of the cooling tower, this hot water, which can reach up to 150°F, is useful and can be utilized in a variety of heating applications that, until a few years ago, were the domain of boilers and heat pumps. Hence, this chiller is commonly called a heat pump chiller.

Although the advantages of this type of chiller are enormous, not every facility is a good fit, since not all facilities require simultaneous heating and cooling. Large facilities with 24-hour operation, such as hospitals, hotels, and universities, which have year-round demand for both heating and cooling, have tremendous potential to save energy. However, a careful examination of the loads throughout the year is prudent, in order to ensure that the heating and cooling produced by these chillers will be sufficiently utilized.

In addition, the second compressor can be turned off when the heating load is low. Although this will reduce the temperature of the condenser water leaving the chiller, it can be hot enough to meet the requirements of summer heating applications, such as reheat and domestic water, which typically do not require the high temperatures associated with winter heating. This will also allow the chillers to operate more efficiently, in the same way as a standard single compressor centrifugal chiller.

Geothermal Storage

Many facilities require simultaneous heating and cooling, but utilize only a fraction of its peak heating during the summer. In this case, a heat pump chiller can still offer tremendous benefits with the addition of a renewable technology called geothermal storage. This allows a facility to store the heat it produces in the summer and use it in the winter. This is achieved by heating the earth several hundred feet below the ground inwhat is called a loop field. This loop field is an area of land with several bores that are several hundred feet deep. Each bore houses u-shaped pipes that routes hot water and cold water down deep into the rock in the earth where it rejects or obtains load. This bedrock is an excellent thermal storage device. It can be charged with heating energy during the summer, hold this heat with minimal losses, and discharge it for utilization in the winter.

The Application

System Sizing

By examining the heating and cooling loads provided by university personnel (see Appendix A), a heat pump chiller plant with geothermal storage, including all distribution piping, was sized to meet the needs of the university's campus. Calculated by CM Engineering, the estimated annual electrical consumption for this system will be 50 million kWh and the annual operating cost will be $2.1 million.

System Layout

Three locations are proposed for the new heat pump chillers: a new energy centre on the east side of the campus, and a new second energy center on the north side of the campus, and the third existing energy center on the south side of the campus. The new heat pump chillers can be connected directly to the existing chilled water piping system. A new hot water piping loop will need to be added to carry the hot water to the buildings. The source of the hot water, the three heat pump chiller plants, will be connected to this new hot water piping loop with branch pipes. Additional branch pipes will connect this loop to the destination of the hot water, the hot water side of the heat exchangers that currently use steam to provide hot water inside the buildings. For the buildings that do not have these heat exchangers, new air handling unit coils and terminal equipment will need to be installed, in order to accommodate the hot water. The current district heating and cooling system will remain in place and operational during the conversion.

A flow diagram of this system is shown in Appendix B. The system will provide 44°F chilled water throughout the year, and 150°F hot water in winter design conditions (with both compressors running). The hot water temperature will decrease proportionately with the outside air temperature, to a minimum of 110°F in summer design conditions (with one compressor running). This hot water will be used for domestic hot water and summer heating applications, which do not require the hotter 150°F water.

The hot water is circulated using variable frequency drive (VFD) pumps to the existing buildings until their immediate needs are met. If any heat is remaining, it is routed to a heat exchanger that deposits heat into the geothermal storage. This typically occurs during the summer. Conversely, during the winter, when an additional heat source is needed, heat is removed from the geothermal storage.

The specifics on the loop field are contained in Borehole Design Report in Appendix C. It is estimated that 3,750 bores will be needed. They will be 400 feet deep and 15 feet apart from each other. They will house two 1-inch u-bend pipes per bore. The grout thermal conductivity, which is a measure of how effectively the bedrock can hold heat, is estimated to be 0.84 Btu/hr·ft·°F.

Conclusion

It is clear that heat pump chillers with geothermal storage offer tremendous potential for energy savings for Ball State University. It is our hope that this report will offer some helpful information, as we continue to perform further analysis on this type of system to meet the heating and cooling needs of the campus.

Appendix A: Heating and Cooling Loads

Building Name	Address	Year Built	Area (ft^2)	Heating Load (MBtuh)	Hot Water (gpm)	Cooling Load (tons)	Chilled Water (gpm)
Carmichael Hall	1701 W. McKinley	1967	22,963	574	38	58	138
Johnson Hall (JA Botsford-Swinford; JB Schmidt-Wilson)	1601 N. McKinley	1967	262,432	6,561	437	141	338
LaFollette Halls (Village Expansion)	1515 N. McKinley	1964	531,792	13,295	886	211	507
Lewellen Pool	1400 N. McKinley	1967	56,415	1,410	94		0
Health/Phys Activities Building	1740 W. Neely	1989	110,710	2,768	185	186	445
Irving Gymnasium	1700 W. Neely	1962	135,039	3,376	225	186	445
Worthen Arena		1990	193,267	4,832	322	448	1,075
Architecture	1212 N. McKinley	1970	146,750	3,669	245	333	799
Subtotals				**36,484**	**2,432**	**1,562**	**3,748**
Robert P. Bell Building	1211 N. McKinley	1982	106,500	2,663	178	141	338
David Letterman Building	1201 N. McKinley Ave	2005	86,351	2,159	144	128	307
Edmund F. Ball Building	1109 N. McKinley	1986	84,594	2,115	141	256	614
Arts and Journalism Building	1101 McKinley	2000	207,141	5,179	345	218	522
Bracken Library	1100 N. McKinley	1972	321,800	8,045	536	640	1,536
University Theatre	920 N. McKinley	1960	83,667	2,092	139	179	430
Teachers College Building	901 N. McKinley	1966	125,650	3,141	209	288	691
Noyer Hall	1601 W. Neely	1962	238,320	5,958	397	448	1,075
Woodworth Halls	1600 W. Riverside	1956	164,626	4,116	274	202	484
Pruis Hall	1000 N. McKinley	1971	18,170	454	30	128	307
Bracken House	2200 W. Berwyn Rd.	1937	13,227	331	22	19	46
Whitinger Business Building	1200 N. McKinley	1978	93,763	2,344	156	160	384
Studebaker Halls East	1301 W. Neely	1965	97,406	2,435	162	51	123
Studebaker Halls West	1401 W. Neely	1964	242,080	6,052	403	294	707
Park Hall	1550 Riverside	2006	194,600	4,865	324	282	676

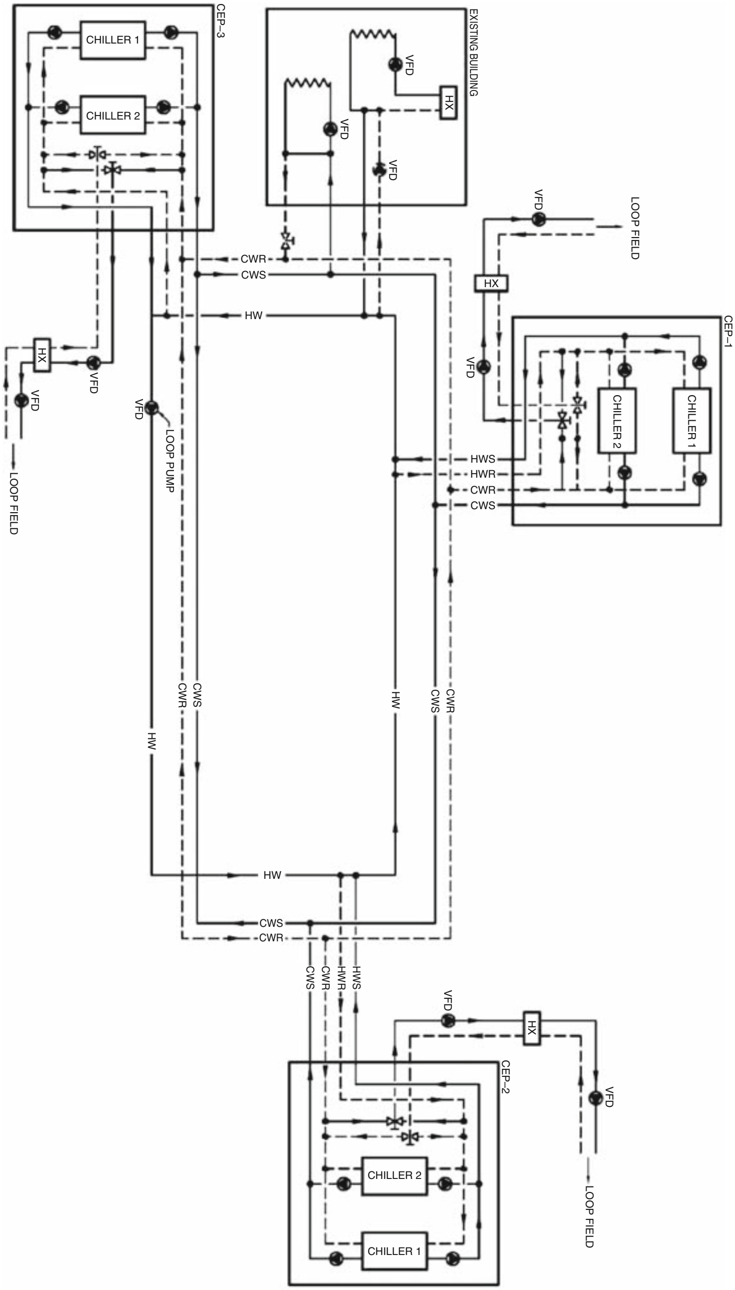
(*continued*)

Appendix A (continued)

Building Name	Address	Year Built	Area (ft^2)	Heating Load (MBtuh)	Hot Water (gpm)	Cooling Load (tons)	Chilled Water (gpm)
Music Building	1810 W. Riverside	1956	45,036	1,126	75	83	200
Music Instruction Building	1809 W. Riverside	2003	86,179	2,154	144	179	430
Emens Auditorium	1800 W. Riverside	1963	82,101	2,053	137	243	584
Arts and Communication Bldg.	1701 W. Riverside	1957	47,010	1,175	78	83	200
Health Center	1500 W. Neely	1962	19,527	488	33	32	77
DeHority Halls	1500 W. Riverside	1960	138,140	3,454	230	205	492
North Residence Hall	1400 W. Neely	2008	190,480	4,762	317	230	553
Subtotals				**67,159**	**4,477**	**4,490**	**10,775**
North Quad	1901 W. Riverside	1926	126,543	3,164	211	294	707
Applied Technology	2000 W. Riverside	1948	93,274	2,332	155	205	492
Fine Arts Building	2021 W. Riverside	1935	74,085	1,852	123	198	476
Cooper Physical Sciences	2111 W. Riverside	1965	130,090	3,252	217	461	1,106
Cooper Nursing	2111 W. Riverside	1965	47,580	1,190	79	122	292
Cooper Life Sciences	2111 W. Riverside	1968	113,843	2,846	190	442	1,060
Ball Gymnasium	Campus Drive	1939	83,197	2,080	139	115	276
West Quad	2301 W. Riverside	1936	57,593	1,440	96	109	261
Lucina Hall	2120 W. University	1927	60,014	1,500	100	128	307
Burris School	2201 W. University	1928	130,745	3,269	218	250	599
Elliott Dining	2100 W. Gilbert	1990	13,228	331	22	45	108
Wagoner Halls	301 N. Talley	1957	75,680	1,892	126	13	31
Elliott Hall	401 N. Talley	1937	51,627	1,291	86	32	77
Administration Building	2000 W. University	1912	54,136	1,353	90	96	230
Student Center	2001 W. University	1951	171,165	4,279	285	410	983
Burkhardt Building	601 N. McKinley	1924	61,439	1,536	102	70	169
Subtotals				**33,606**	**2,240**	**2,989**	**7,173**
Central Chiller	West Campus Drive	1965	7,909	198	13		
Field Sports Building	1720 W. Neely	1983	47,736	1,193	80		240
Greenhouses	Christy Woods	1965	4,381	110	7		
Heating Plant	2331 W. Riverside	1924	18,685	467	31		
South Service Bldg.	Campus Drive	1967	4,800	120	8		30
Expansion			300,000	7,500	500	640	1,500
Totals			**5,873,486**	**144,749**	**9,650**	**9,680**	**23,196**

Appendix B: Flow Diagram

(June 30, 2009 update: One-pipe distribution system has been changed to a two-pipe distribution system)



Appendix C: Borehole Design Report

Ground Loop Design

Borehole Design Project Report - 1/14/2009

Project Name:	**Ball State**		
Designer Name:	Jeff Urlaub		
Date:	12/9/2008	**Project Start Date:**	12/9/2008
Client Name:	**Ball State**		
Address Line 1:			
Address Line 2:			
City:		**Phone:**	
State:		**Fax:**	
Zip:		**Email:**	

Calculation Results

	COOLING	HEATING
Total Length (ft):	132224.6	145224.0
Borehole Number:	375	375
Borehole Length (ft):	352.6	387.3
Ground Temperature Change (°F):	+1.2	+1.1
Unit Inlet (°F):	85.0	45.0
Unit Outlet (°F):	95.2	38.3
Total Unit Capacity (kBtu/Hr):	11119.7	12692.9
Peak Load (kBtu/Hr):	8418.7	12692.9
Peak Demand (kW):	674.3	617.7
Heat Pump EER/COP:	12.5	3.6
System EER/COP:	12.5	6.0
System Flow Rate (gpm):	2104.7	3173.2

Input Parameters

Fluid		Soil	
Flow Rate:	3.0 gpm/ton	Ground Temperature:	56.0 °F
Fluid:	100% Water	Thermal Conductivity:	1.68 Btu/(h*ft*°F)
Specific Heat (Cp):	1.00 Btu/(°F*lbm)	Thermal Diffusivity:	1.12 ft^2/day
Density (rho):	62.4 lb/ft^3		

Piping

Pipe Type:	1 in. (25 mm)
Flow Type:	Turbulent - SDR11
Pipe Resistance:	0.071 h*ft*°F/Btu
U-Tube Configuration:	Double
Radial Pipe Placement:	Along Outer Wall
Borehole Diameter:	6.00 in
Grout Thermal Conductivity:	0.84 Btu/(h*ft*°F)
Borehole Thermal Resistance:	0.156 h*ft*°F/Btu

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Chapter 18
Engaged Learning for Climate Change: The Perils and Potentials of Collaborative Partnerships and Projects

Julie Matthews

Abstract Impeding climate change and climate variability require professionals to develop a range of new skills to address new problems. We argue here that the development of those skills and the knowledge and ability to act sustainably can be generated in processes of engagement with the immediate and complex problems that beset local communities. We further argue that the generation of engaged learning and experiential learning approaches should be accompanied by the opportunity for students to reflect on the big picture questions raised by their enterprise. Based on an account of a suite of modular Masters Degree programs developed at the University of the Sunshine Coast, a regional Australian university, this chapter shows how stakeholder and partnership arrangements serve as the basis of a programme structure that allows students to identify regional problems and devise locally relevant solutions. The chapter further argues that engaged learning in the context of higher education should go beyond individually focused classroom activities to encompass curricula and pedagogical processes which enable collaboration rather than competition. Sustainability literacy from this perspective is not just about changing individual values and behaviour but also concerned with the process by which these are tempered through engagements with others.

Keywords Australia · Collaboration · Partnerships · Skills

Introduction

With real and impending threats posed by global warming and subsequent climate variability and change, professionals are being challenged to develop expertise in environmental decision making and policy development. This chapter discusses engaged learning in relation to climate change adaptation skills in the context of a suite of articulated postgraduate programs recently initiated at the University

W.L. Filho (ed.), *Universities and Climate Change*,
DOI 10.1007/978-3-642-10751-1_18,

of the Sunshine Coast (USC), Queensland, Australia. The Masters of Integrated Coastal Zone Management, Masters of Climate Change Adaptation and Masters of Environmental Change Management are all intended to advance the professional development of students in local, state and national governments, community organizations, urban planning and engineering, resource management, property development and other agencies. This chapter argues that climate change skills, values and aptitudes are advanced through engaged learning or "leaning by doing" pedagogies. These require an understanding of ecosystems and tools required to assess their condition. Importantly they go beyond information transmission and the assumption that core disciplinary and technical knowledge are straightforwardly transferred through uncomplicated processes of teaching and learning. Engaged learning necessarily involves hands-on activities to facilitate knowledge and skills application and adaptation as well as reflections and awareness that processes of engagement are of crucial significance.

Derived from the work of John Dewy engaged learning has followed two main streams of thought and practice. The first relates to experiential and enquiry-based approaches commonly found in "environmental education", "outdoor education", "service learning" and "experiential education" (Knapp 2005). Experiential learning is based on the idea that students learn better by doing and through engagement with, and reflection on meaningful activities intended to devise solutions to real world problems (Quay 2003). The second concerns the "scholarship of engagement" work of Ernest Boyer who calls for universities to renew their relevance and their service function by producing knowledge able to address real world problems (Barge and Shockley-Zalabak 2008).

The new professional development climate change courses deliver key content information which is not difficult to locate and assess at the level of individual students. Students learn about ecosystems and their evaluation so that they can comprehend issues of ecological variability and change and the importance of understanding current conditions, facilities, and operational activities. For example, learn about integrated environmental management, climatological and hydrological systems dynamics, and coastal systems and they become familiar with tools necessary to undertake environmental assessments and audits of facilities and operational activities that review potential effects of climatic variability and change on water yield of selected catchments. They learn how to assess climate risk in relation to settlement and infrastructure and natural heritage values, and they undertake coastal vulnerability and adaptation assessments.

A wide range of adaptation actions are also examined. These may involve technology such as in the case of sea defence constructions, behaviour as in changes in choice of food consumption, management as in changes to farming methods and policy in relation to planning regulations. Assessment and the identification of adaptation actions frequently cut across multiple activities and involve multiple stresses such as in the case of water resource, agriculture, coastal and disaster management (Vogel 2008). An engaged learning approach offers an important way of developing deep understandings of complex systems by principally seeking to clarify the nature of local problems with a view to identifying sustainable solutions. The application and adaptation of new knowledge and skills are not simply generated through the remote application of theoretical knowledge, but tempered through intricate day-to-day understandings of interrelated conditions.

The process of engaged learning is important because it facilitates dialogue, cooperation and enhances community and capacity building as well as locating educational activity in the lives and experience of students themselves as well as the everyday world of local communities and organizations. This nested process generates the possibility of new ways of naming and acting for change (Freire 1972). The pedagogical point to be made here is that how and why we teach is as significant as what we teach and the knowledge, skills and ability to understand and act in favour of sustainability can be usefully generated in processes of engagement with the immediate and complex problems that beset local communities.

Fifty percent of course work in the masters programs comprise practical problem-solving projects. While collaborative engagements with other students, other professionals and with regional organizations and agencies create ownership and increase motivation and commitment to sustainability, they are not easy to pin down through traditional process of assessment which focuses on individual student ability, rather than their ability to collaborate and develop skills such as problem solving, conflict resolution and teamwork. The competitive individualist achievement orientation of higher education is not well placed to endorse and encourage cooperation directed towards the greater social good over personal academic achievement. The competitive ethic of higher education is also undermined by the need for collaborations to be open to examining their limits though processes of critical reflection. Below we develop these arguments further and discuss programme rationale in relation to necessary content knowledge and issues of engaged learning.

Climate Change and Coastal Zones

The threat of global warming and its devastating impacts to coastal communities, food and water supplies, human health and infrastructure, natural and cultural diversity, and the global economy is imminent. The Stern Review warned that failure to avert the consequences of global warning would result in a worldwide recession (Stern 2006). The Garnaut Report (2008) pointed to the physical, biological, economic and social risks and consequences of increasing greenhouse gas concentrations, and the highlighted need for immediate action. The IPCC (2007) observed that changes to the climate were more rapid than anything the Earth had experienced for 1,800 years and called for climate change adaptation and mitigation.

Worldwide, millions of people live in coastal zones, and in Australia some 85% of the population live within 50 km of the shoreline. It is in coastal zones where human and natural forcing factors have greatest impact (Waterman 1996). These include:

- Rapid population growth and the accelerated expansion of settlements and the accompanying pressures on natural and production systems arising from changing land uses including urban and industrial developments
- The potential threats and risks arising from climate variability and change to food production systems, the provision of potable water, public health, infrastructure, and habitats of plant and animal species
- Biophysical and socio-economic impacts on environmental conditions and values that can be attributed to primary and secondary industries and urban development
- Extreme natural events and unmanaged human activities that contribute to the loss of visual amenity, degradation and loss of heritage and cultural values, extinction of species and reduction in the spatial extent and quality of habitats for all life forms

Climate change is the major threat to the sustainability of natural and human systems (Waterman et al 2000). Changed climatic conditions and increasing population pose risks to biodiversity, food and water security, human and environmental health and to patterns of settlement and infrastructure (White and Waterman 2006).

International and national responses point to the need to mainstream adaptation strategies into policy, plans and on-the-ground actions. In turn, this has led to the need to provide new and enhanced information, knowledge and skills across all sectors of civil society. Professionals from a wide range of disciplinary backgrounds urgently require skills for climate change adaptation if sustainability policy, planning and actions are to be mainstreamed. Globally, too, governments and civil society are becoming informed and involved in implementing immediate measures to deal with the challenges and changes presented by climatic variability. Initiatives implemented to understand and report on dimensions of environmental change, illustrated by state-of-the-environment, sustainability and "triple-bottom-line" reporting include activities that formally monitor and report on changing conditions at national, regional and local levels. Additionally, a number of capacity building programs have been initiated by government departments and agencies, universities, and training providers to address immediate professional development needs. A key barrier, however, is the level of professional capability and capacity available to governments, industry and communities.

Rising to the Challenge: An Integrated Approach

In the context of population and settlement pressures in coastal zones, and in response to the urgent need for tertiary qualified trans-disciplinary practitioners, the suite of linked, nested and fully articulated undergraduate and postgraduate programs developed at USC are intended to more effectively equip professionals to proactively address climatic variability, change, inherent risks, vulnerabilities, impacts and adaptive responses especially. These are shown schematically in Fig. 1.

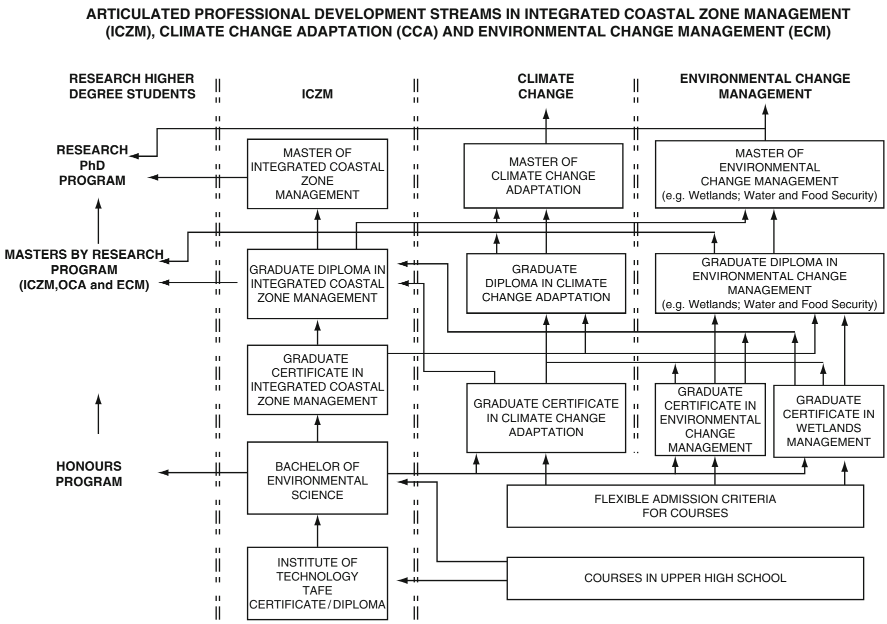

Fig. 1 Articulated professional development streams in integrated costal zone management (ICZM), climate change adaption (CCA) and environmental change management (ECM)

The strong professional development focus is provided by projects and work-integrated learning courses that extend learning and skills acquisition to applied situations. Importantly, the programs are engaged and linked to community, government and industry, thereby providing a robust basis for addressing specific regional and local need as well as advancing knowledge and skills required to address mainstreaming climate change adaptation into policy, planning and sustainable development proposals, programs and projects. Conceptually, the programme addresses the three interrelated areas of activity shown schematically in Fig. 2.

The fundamental research and research training aspect is supported by competitive and other grants such as from The Australian Government Department of Climate Change on the Climate Change Adaptation Skills for Professionals Program. This has facilitated connections with other universities and training providers from various industry sectors. Applied research and climate proofing demonstration projects are delivered through consultancy services. For example, the South East Queensland (SEQ) "Climate Proofing" Demonstration Project is undertaken in collaboration with two major natural resources management bodies (SEQ Catchments and the Burnett Mary Regional Group). This aspect of delivery has also forged strong links between students and staff from USC, Regional Councils and communities, resulting in the generation of a range of publicly accessible information materials and facilitated community meetings and workshops. These interlocked areas of activity are, in turn, underpinned by teaching and learning,

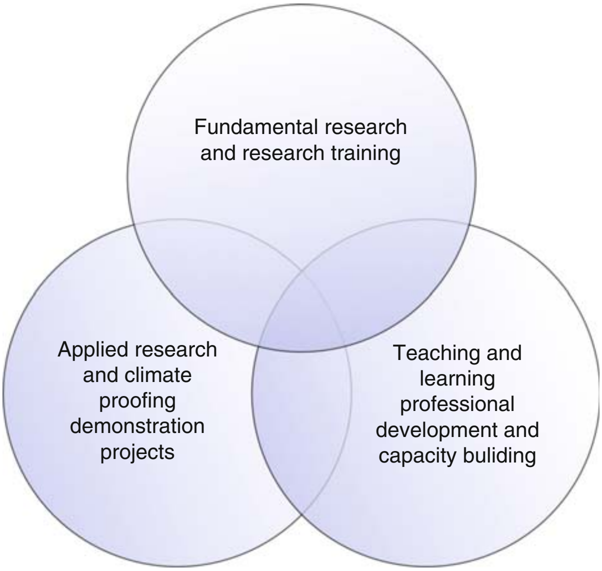

Fig. 2 Climatic and environmental change activities at USC

professional development and capacity building delivered through a combination of accredited postgraduate programs (course work and research), undergraduate courses, professional short courses and technical training at institutional and community levels.

Collectively, these areas of activity provide a strong basis from which to educate a new generation of professionals committed to the delivery of community-engaged action for sustainability. Additionally, they serve as vehicles for raising the public and private sector community and individual awareness, understanding and confidence necessary to meet the challenges of climatic variability and change.

Engaged Learning

Engaged learning is based on experience and processes of active enquiry and involves the creation of knowledge through involvement in particular contexts and conditions. "Active learning", "learning by doing", "discovery learning", "situated learning" " place-based education" all refer to forms of leaning engagement intended to enhance interaction, motivation, and responsibility. Place-based education is a term coined by Smith (2001) to refer to "environmental education", "outdoor education", "service learning" and "experiential education". Following the work of American ecologist and environmentalist Aldo Leopold, place-based learning relies on experience and interdisciplinary knowledge of the land to enhance sensitivity to nature, aesthetics and ethics (Knapp 2005). Situated learning is another variant of engaged learning and seeks to address misunderstandings that may arise from decontextualised knowledge by locating understanding in the specific conditions and of “communities of practice”. Communities of practice refers to groups of people who share learning practices such as a group of engineers or managers working on similar problems and issues (Wenger 2007).

Engaged learning approaches are thus based on the idea that direct engagements with particular places and locations automatically generate connections and commitment. However, engaged learning approaches rarely interrogate assumptions implicit in the kinds of problems identified and the kinds of solutions devised. In other words, they do not interrogate the historical and cultural preconceptions upon which assessments of the issues and problems are based. It is important for engaged learning approaches to critically interrogate practices and proposed solutions for several reasons, first so that mundane or piecemeal solutions do not end up replacing awareness of the need for more radical and fundamental reorganisations, and second because a focus on immediate concrete experience often fails to apprehend the limited perspectives implicit in empirical experience. Following Dewey, experience is necessarily imbued with cultural and historical interpretations and rather than reflecting “real” empirical conditions, it may simply comprise perceptions based on established traditions and “common sense” cultural practices. This is why engaged learning should involve critical reflection and analysis of those historical, philosophical, cultural, social, and psychological conditions that make “experience” comprehendible.

Collaborating agencies and organizations may not fully appreciate the necessary elements of Dewey’s enquiry-based process. For Dewey, primary experience and the habits and routines of everyday life are the bedrock of experience and problems, crisis and uncertainty occur when these begin to fail, as with the current crisis of sustainability. These circumstances require objects that were previously familiar and “known” to be interrogated as objects of reflection and enquiry. They require a working hypothesis to be formulated and tested through thought experiments, available literature, knowledge and resources. Only after rigorous enquiry should a solution be applied in practice. Even if the solution does not resolve the problem, an indirect outcome of engaged learning is a process of meaning production that can be used to address future situations (Miettinen 2000, p. 67).

The full implications of engaged learning may equally be neglected by higher education institutions. It is often assumed that engaged learning is fundamentally based on individual achievement and can thus be easily tacked onto traditional higher education learning and assessment practices. However, while engaged learning is based on individual intellectual development, its social components also challenge individualism and underlines the significance of collaborative enterprise. Engaged learning involves processes of interaction between teachers, peers, educational settings, workplaces and cultural discourses (Quay 2003). It relies on cooperation, problem solving, conflict mediation and teamwork, skills that individually focused, competitive university assessment frameworks have difficulty coming to terms with. Universities still reward individual achievement over collaboration and are poorly placed to nurture scholarship for the greater social good. The competitive ethic also has an ambivalent effect on the capacity of students to engage critically with those cultural, historical, philosophical, and religious discourses constrain understanding and limit our ability to apprehend and approach problems differently (Miettinen 2000).

The scholarship of engagement approach seeks to connect academic scholarship to the production of knowledge for the greater social good (Boyer 1996). It supplements the archetypal *scholarship of discovery*, comprising basic research interested in advancing human knowledge, with three additional forms of scholarship. The *scholarship of integration* involves the meaning making processes by which knowledge is integrated into various practical and disciplinary and interdisciplinary contexts to illuminate and educate, the *scholarship of application* is the application of knowledge to various practical problems, and the *scholarship of teaching* transmits, transforms, and extends knowledge.

Boyer argues that the engagement of university scholarship with contemporary social problems will make higher education a key focus of social action, change, innovation, and creative scholarship. A challenge for engaged learning is first how to sustain reflection so as to keep scholarship open to new cultural paradigms and alternative solutions and second how to remain tuned into big picture questions while responding to regional problems and solutions. One immediate obstacle concerns the ethical biases and risks associated with collaborative research where partners may have vested interests in producing certain kinds of knowledge well as limiting the circulation and access to knowledge in order to secure profits and monopolies.

Conclusion

Our present predicament is unprecedented and concerns the uncompromising facts of changes which will affect every living organism on the planet over forthcoming decades. We have in this chapter sought to show how engaged learning can be related to collaborative partnerships and project activities in regional locations to provide the basis for the development of sustainability literacy skills necessary to address climate change. The professional development approach described here requires flexibility and integration so that courses and programs can mix, match and adapt a combination of frameworks, concepts and methods (Gupta 2007 cited in Vogel 2008). Pathways to action are opened through engaged learning tied to real life situations through community engagements, partnerships and projects. While we suggest that the approach makes a valuable contribution to developing climate change adaptation skill and understanding new dimensions of sustainability literacy, we also point to the difficulties of pursuing engaged learning in a higher education system characterised by competitive individualism in learning and assessment practices, a system more interested in final and measurable outcomes than processes which enable critical reflection on the historical and cultural and philosophical forms of thought and practice that have led to our current predicament; and finally the contradiction of partnerships and collaborations where businesses and other organizations may be more concerned with immediate profits than the greater social good.

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Chapter 19
Learning for Climate Responsibility: Via Consciousness to Action

Anne Virtanen

Abstract Climate change is one of the main issues in learning for sustainable development. This article is based on a study that focused on determining pedagogical approaches of education for sustainable development (ESD) according to the research results in Finnish higher education institutions. As a result a pedagogical model of ESD was developed. In this article I apply this model to education for climate responsibility. The pedagogical model of ESD consists of six main features: (1) interaction and co-operation, (2) linking-thinking, (3) critical reflection, (4) participation, (5) spatiality and time-scale and (6) knowledge and skills. By linking these features as approaches and as learning aims in teaching, competence building for sustainability and climate responsibility can be realized. In addition to theoretical viewpoints the article describes examples (part of study courses, educational situations and tasks) of how to apply these pedagogical approaches to learning situations concerning climate change and responsibility in higher education.

Keywords Climate change · Climate responsibility · Education for sustainable development · Higher education · Pedagogical approach

Introduction

Climate change is a concern for international organizations, national governments, businesses, non-governmental organizations, societies and individuals all around the world. For example, according to a survey 86% of Finnish people think that climate change is the biggest environmental threat of our time (Johansson et al 2007, p. 1). We are in a dilemma, as on the one hand, we call for effective economic development and ever growing stock markets but, on the other hand, the natural systems we depend on may collapse (Rohweder 2008). Climate change is one of the most obvious and acute of the threats.

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The role of competence building in climate change should be, and has been, cause for lively debate, because we need new competences not only to think in a climate-responsible way but also to act in the fight against climate change. Scientists share the opinion that economic development and western lifestyle over the course of more than a century has increasingly emitted greenhouse gases to the extent that the entire planetary climate system is changing. The public discussion and stakeholders' increasing interests have pushed companies, societies and politicians to take an active role in the process to promote mitigation and adaptation practices of climate change. Although proactivity in climate responsibility is increasing, it is still relevant to ask how to act in a sustainable way and which competences are needed (Rohweder 2008).

In the process of mitigating climate change and developing the methods to adapt the impacts of climate change, institutions of higher education can choose between two different roles. According to the first one, institutions of higher education are merely indicators of changes in attitude, knowledge and practices within a society, and do not themselves provide the impetus for change. The basic assumption behind this thinking is that higher educational institutions are created by society, and are therefore a reflection of it and are in no way a real force for social change (Wright 2006). The other view notes that institutions of higher education can and even should be proactive leaders in promoting societal change (Giroux 2005; UNESCO 1997). This article represents this proactive point of view, and highlights which pedagogical approaches are useful in enhancing learning for climate responsibility in higher education.

In this article, I will first describe the results of the study in which the pedagogical model of education for sustainable development was developed and connect it to education for climate responsibility. At the end, I will introduce some examples of educational situations in which the pedagogical approaches included in the model were connected to competence building for climate responsibility.

Pedagogical Approaches of Education for Sustainable Development to Promote Climate Responsibility

Theoretical reflections introduced in this chapter are based on the development work done in Finland during the years 2006–2008 (see Rohweder and Virtanen 2008). The theoretical but also practical aim of the development work was to develop a pedagogical model of education for sustainable development in the context of higher education. The critical factors of learning for sustainability according to Tilbury and Cooke (2005) and Tilbury and Ross (2006) served as a starting point for the development work. Tilbury and Cooke (2005) have defined the critical factors of learning for sustainability as follows: envisioning a better future, systemic thinking, critical (reflective) thinking, participation in decision making as well as networks and partnerships for change. In addition, future orientation, value clarification, cultural thinking, participation in planning and learning, relevance and capacity building should be taken into consideration in the learning process for sustainability (Tilbury and Ross 2006). Similar approaches are introduced by UNESCO in the declaration of the DESD, which highlights that ESD should be interdisciplinary and holistic, values-driven and locally relevant, and it should promote critical thinking and problem solving skills (UNESCO 2004).

During the development process the project group analyzed, discussed, argued, and finally specified the important pedagogical approaches. As a result, a model of education for sustainable development was developed. The main questions during the development process were:

- Are the introduced critical factors for learning for sustainable development relevant in the Finnish higher educational context?
- Are some relevant factors missing?
- How to combine, connect or remove factors?

In addition to the project group meetings, a quantitative study was made, workshops were organized for pedagogical experts and a great deal of theoretical literature was read and practical experience gathered (see Rohweder and Virtanen 2008).

As a result of the development process, a model of education for sustainable development was constructed. The model consists of the important factors to be taken into account in education when promoting learning for sustainability: interaction and co-operation, linking-thinking, critical reflection, participation, spatiality and time-scale and knowledge and skills (Fig. 1). The main aim of education is to promote learning for sustainability, i.e., to build competences to promote sustainability at individual, community and societal levels (Rohweder et al 2008, p. 99).

Constructing and mediating *knowledge and skills* for sustainability and climate responsibility constitute a foundation for education for sustainable development. Knowledge of and skills for ecological, economical, social and cultural sustainability are issues for every educational field in higher education. Having the knowledge and skills for sustainability and climate responsibility, there is an increase in motivation to collect more information, act towards sustainability and change society for more sustainable future. Attitudes, knowledge and skills are intertwined; knowledge simulates and stimulates for future actions, and motivation is an inspiration to collect knowledge and skills for sustainability and climate responsibility.

Spatiality and time-scale forms a context for education and other activities. In addition, spatiality and timescale are the dimensions to take into account as perspectives and as learning competences in education for sustainable development. *Spatiality* is important in the discussion of sustainable development, and it has a special meaning in the discussion of climate change as well. Learning for sustainability needs a transgeographical shift, i.e. looking at sustainability issues from local to regional and global perspectives (Wals and Corcoran 2006). The glasses to analyse and interpret are global, but at the same time the interest to manage, handle and reconstruct practices is locally oriented.

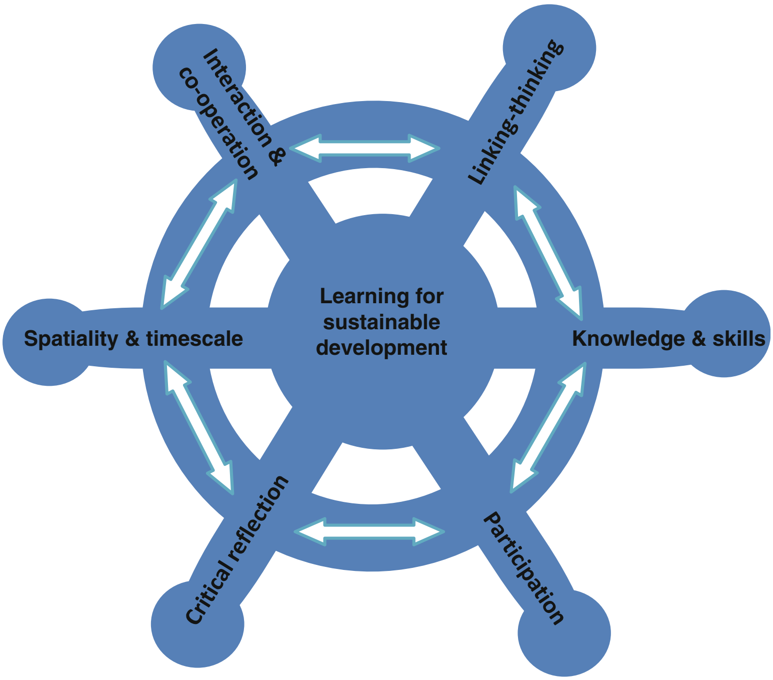

Fig. 1 A model of education for sustainable development (Rohweder et al 2008, p. 99)

Time-scale is one focal aspect in education for sustainable development including trans-/intergenerational shifts in accordance with looking at sustainability from different time perspectives, i.e., past, present and future (Wals and Corcoran 2006, p. 107; Rydén L 2007 , p. 30). Future thinking is most essential, but without adopting knowledge about the causal links and reasons for unsustainability it is hard to construct a sustainable future. Future thinking is an envisioning process in which people conceive qualities for a better and more sustainable future – the question is about imaging a better future (Tilbury and Cooke 2005, p. 23). Tilbury and Ross (2006, p. 19) have argued that envisioning should be the starting point of learning for sustainability in which people begin to feel engaged, empowered and responsible to act in ways to reach their vision for a sustainable future. The aim of envisioning is to create a constructive, positive and proactive approach to sustainability. Climate change is not only a threat – it can also be a possibility.

Interaction and co-operation as well as participation refer to the ways to organize education and what kind of learning competences should be promoted for sustainability and climate responsibility. The demand of sustainability and climate responsibility requires a new kind of co-operation and interaction with many partners. Partnerships can be established between educational communities, public organizations, non-governmental organizations, local communities, entre-preneurs, etc. By bringing together different groups from different sectors with diverse knowledge and skills, partnerships can build collective knowledge through social learning. Ideally, the partnerships for sustainability are based on a collaborative culture where trust, open dialogue and communication, defined and accepted roles, transparency and accountability as well as equity and fairness are the main characteristics (see Tilbury and Ross 2006). Teamwork and collaboration between disciplines offer possibilities to see beyond separate disciplines, to combine knowledge and define new multidiscipline concepts and solutions for sustainability.

Participation requires involvement on different levels starting from consultation and consensus building to decision making, risk sharing and collective partnerships. In education for sustainable development, participation is connected to decision making for sustainability and to the wide participation of students and other stakeholders in the learning process. Through participation people can build knowledge and skills as well as take responsibility for outcomes. Active involvement and dialogic discussions are essential characteristics of participation. Participation is an important instrument to recognize the value and relevance of local and context-specific issues (Tilbury and Cooke 2005). By using various learning tasks that involve teamwork, a great deal of discussion and shared responsibility, the participatory characteristics of teaching, can be strengthened.

Two other dimensions of the model of education for sustainable development, linking-thinking and critical reflection, are most of all "thinking skills", which means that they are mental competences for sustainability and climate responsibility. *Linking-thinking* (systemic thinking, holistic thinking) is an important complement to analytical and critical thinking: approaches to problem solving and ways of thinking that are more holistic, systemic, inclusive and integrative. From global to local levels the issues and problems are complex, interrelated and not easily solvable, and therefore linking-thinking is needed (see Sterling 2005). Linking-thinking challenges us to formulate higher education according to the principles of interconnectedness, holism, interdisciplinarity and cross-curricular approach.

Critical reflection challenges us to find a new interpretation for our lifestyles, communities, societies and the whole world. Reflection can be viewed as a critical self-evaluation and analytical reasoning of our work, thinking and everyday practices. Critical reflection also means discussions and open dialogues with colleagues. In addition, reflecting and discussing with unfamiliar people from different cultural and social backgrounds opens minds. A critical viewpoint encourages us to reconstruct our understanding of the world and its political, economic and social structure (Tilbury and Cooke 2005). Critical reflection on its highest level demands to question the preconceptions of issues and create new or modified interpretations to understand and realize activities for sustainability and climate responsibility.

Competence Building for Climate Responsibility

Competence building for climate responsibility is a result of the learning process in education for sustainable development. Competence building equips individuals with the motivation, understanding, skills and access to information, knowledge

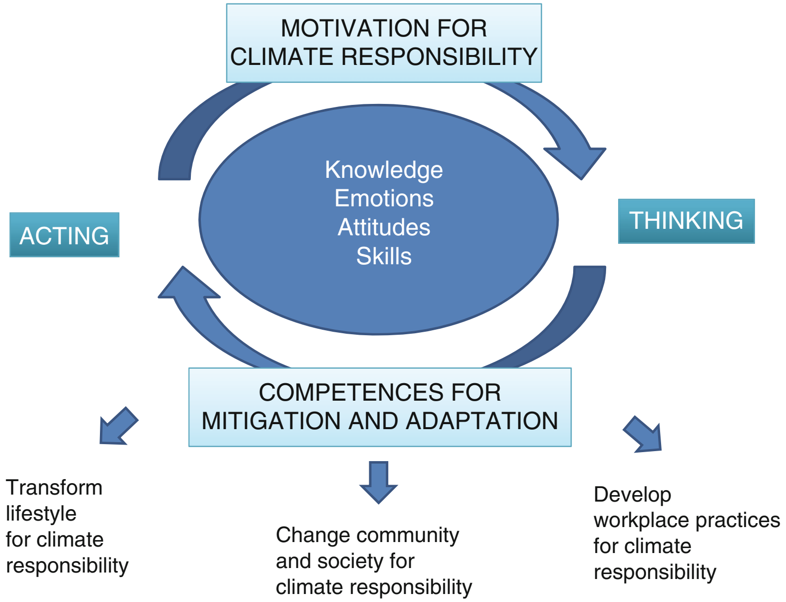

Fig. 2 Competence building for climate responsibility

and training, which enables them to act towards climate responsibility. In the process of competence building, a person's knowledge of climate change, changes in emotions and attitudes towards climate issues, as well as skills for behaving and acting in a responsible way develop. The result is to adopt motivation and competences to think and act for climate responsibility. Having competences for mitigation and adaptation leads to the transformation of lifestyles, workplace practices and communities towards climate responsibility (Fig. 2).

Practical Implementations

I will now introduce the issues and questions which can and should be taken into account when reflecting the theoretical model to practical implementations in higher education and what kind of learning situations the pedagogical approaches have been connected and are possible to connect. The examples are from Hamk University of Applied Sciences from the Degree Program of Sustainable Development. The programme focuses on the ways to understand the causes for unsustainability and the ways to develop the world towards sustainability. Many additional issues are, of course, also studied. During the course, students become familiar with the functionality of nature, ecosystems, society and economy.

Practical implementations of education for climate responsibility in the area of knowledge and skills:

– Students define climate change concepts
– Students seek information concerning the impacts of climate change on economical, ecological, social and cultural conditions
– Students learn about the ways to mitigate greenhouse gas emissions, new technological possibilities and new ways of production and consumption
– Students discuss adaptation policies and practices

Example: In the Curriculum of Sustainable Development on the course "Principles and Applications of Sustainable Development" the students used the Internet to find concerning climate change and political decisions made to mitigate greenhouse gas emissions. After that, the students familiarized themselves with the practices concerning adaptation or mitigation of climate change in business, in public organizations or in communities. In the end the students presented their findings and had a lively discussion.

Practical implementations of education for climate responsibility in the area of spatiality and time-scale (see also Breiting et al 2005):

– Students work with visions and scenarios of climate change, seeking alternative ways of development and changes for the future
– Students get involved in comparing local, regional and global as well as short-term and long-term effects of decisions and alternatives of adaptation and mitigation strategies
– Students seek relations between the past, the present and the future, as well as between the local, regional, and global level, in order to get a historical and spatial understanding of climate change
– Students work with planning as a way to reduce future risks, mitigate climate change and adapt to it and to accept uncertainty

Example: During the course "Principles and Applications of Sustainable Development" one task was to prepare posters. The theme was: "Towards sustainability". First, the students studied statistics and determined development in Finland during the last few decades from an environmental, economic, and social point of view. After that they chose the main indicators to describe the development and envisioned a more sustainable and climate-responsible future. The task was a way to understand the contemporary situation by reflecting it on history. The task was an example of an envisioning process as well.

Practical implementations of education for climate responsibility in the area of interaction and co-operation:

– Students cooperate with teachers and work representatives in order to develop, exchange and construct ideas and innovations relevant for business or society as a whole to mitigate and adapt for climate change
– Students, teachers, and the whole university cooperate with institutions relevant to the issue of climate change

Practical implementations of education for climate responsibility in the area of participation:

- Students take part in decisions for actions concerning projects to have an influence on the problem related to climate change, and they learn as a result of reflecting from their experiences
- Teaching focus lies on authentic circumstances, on authentic problems in real-life situations and experiences from real actions, for instance challenges of climate change in business
- Teachers' focus on students' capacities needed for meaningful participation and cooperation, e.g., listening, expressing points of view, taking responsibility and showing solidarity
- Students become experienced in democratic participatory processes

Example: Two students have written their thesis as part of the development project in which the climate strategy was constructed for the city of Lohja in Finland. The students, teachers and representatives from industry discussed the process actively. All participants offered their expertise to the project, and at the same time the participants learnt from each other. The process was educative for the students as they learnt "real-life" practices in authentic circumstances, while the representatives from industry gathered fresh and innovative ideas to their climate strategy.

Practical implementations of education for climate responsibility in the area of linking-thinking (see also Sterling 2005):

- Students look for connections and patterns between the impacts of climate change and learn to think of climate change as having impacts on social, economic and ecological systems
- Students should have a critical perspective on the ways to handle climate change and they need to have a synthetic outlook by understanding the linkages
- Students look for multiple consequences and scenarios of climate change
- Students learn about climate change as a global issue having local impacts and reasons
- Students learn about relationships between systems; economic, environmental and social questions are intertwined
- Teaching is based on seeking out relationships, multiple influences and interactions

Practical implementations of education for climate responsibility in the area of critical reflection (see also Breiting et al 2005):

- Students think reflectively about conflicting interests and impacts of climate change in the local, regional and national context as well as between present and future generations
- Students are encouraged to look at climate change and issues connected to it from different perspectives and to develop empathy by identifying themselves with others

- Students are encouraged to give arguments for different positions and different attitudes and practices for fighting against climate change and its negative impacts
- Students are encouraged to imagine new possibilities and alternative actions for mitigating and adapting for climate change
- Students value other people's views and perspective on climate change
- Students are motivated to be open-minded
- Teacher focus on students' value clarification and strengthening reflection, mutual respect and understanding of other values and power relations behind values

Example: In the course "Principles and Applications of Sustainable Development" the students reflected theoretical facts of climate change to their own lifestyle. The students were encouraged to be critical and have an open-minded attitude. After self-reflection the students were directed to discussion with each other. The students needed to introduce their own climate-responsible/non-responsible behaviour, argue the reasons for it and give new ideas of more climate-responsible ways to be and act. In addition, the students had to give comments to each other, having a mutual respectful attitude. The result was that reflection and discussion skills were improved and the students learnt that "right" answers are hard to find.

In education for climate responsibility a teacher's role is to

- Listen to, reflect on and open new dialogues concerning climate change and ways to handle it in everyday life, in working life situations and wider in community and in society
- Encourage cooperative, collaborative and experiential learning
- Link practical activities, such as research and development projects, to students' concept development and theory construction
- Facilitate students' participation and provide contexts for the development of students' own learning, ideas and perspectives
- Operate as a colleague in relation to work life representatives and students in the development projects concerning mitigation and adaptation practices for climate change.

Conclusion

Higher educational institutions need to recognize and acknowledge their contribution to fight, to mitigate and to adapt for climate change and the consequences it enforces. The change towards climate responsibility necessitates that higher educational institutions firstly understand the true meaning of education for sustainable development and climate change as part of it. Secondly, teachers need to be motivated to contribute to it. And thirdly, higher education needs to find a way to make a contribution, which means using proper pedagogical methods to promote learning for competence and motivation building for climate responsibility. As the recent IPCC account of the theory of adaptation to climate change leaves open the possibilities and practices for motivating adaptation and mitigation, the model of education for sustainable development and its practical implementation offer one possibility to build competences and motivation for climate responsibility.

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Chapter 20
CO_2 Emissions Impact of Sustainable Food Procurement: Informing University Policy

Esther E. Bowen and Pamela A. Martin

Abstract This chapter intends to aid university administrators designing sustainable food policy in dining areas by evaluating the environmental impact of "sustainable" food alternatives – local and organic – using the related environmental metrics "embedded energy" and CO_2 emissions. The authors calculate CO_2-equivalent emissions associated with local and organic options for fresh fruits and vegetables commonly served in a major Midwestern research university dining hall. Emissions savings associated with organic food are narrowly defined as emissions associated with manufacturing agrochemicals customarily used in conventional production. Similarly, averted emissions associated with local food are defined as emissions that can be reasonably attributed to transportation, accounting for both mode and distance. Additionally, energy and CO_2 emissions are calculated for food preservation strategies. The authors advance an approach for quantifying CO_2 impact from food based on three categories of "embedded energy" to facilitate CO_2 reductions in college and university dining halls.

Keywords Case study · CO_2 emissions · Energy · Food · Institution of higher education · Sustainability

Introduction

Sustainability initiatives are increasingly common to universities and colleges across the United States. For sustainable purchasing directives involving food, "local" and "organic" options have emerged as the two available alternatives in the marketplace. However, the marketplace currently lacks widely available, quantitative information regarding the environmental impacts of these alternatives. As a result, the ability of food service officials to make purchasing decisions that definitively reduce environmental impact is limited. Difficulty in evaluating the environmental impact of local and organic foods stems from such circumstances as:

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widely variable conditions in both local and organic systems that preclude generalizations about lower environmental impact; complex food supply chains that limit ability to model and calculate impact of particular food items; and currently a basic lack of information concerning the wider environmental implications of the food system. Within this context, it can be difficult to design and implement effective sustainable food purchasing policies. Often no basis is provided for making decisions about what constitutes "sustainable" for food and the environment within the institutional context. As a result, such programs run the risk of being badly defined. Aside from the environmental harm that this ambiguity inflicts, significant amounts of time, money and administrative energy could be wasted implementing policies that fail to achieve stated goals.

Of the many environmental indicators that contribute to the environmental footprint of food, the use of carbon as a metric for sustainability is becoming the most widely utilized and generally accepted. The food system accounts for $>10\%$ of all U.S. fossil fuel-derived energy consumption, and 20% of all U.S. greenhouse gases (Heller and Keoleian 2000; Eshel and Martin 2009 respectively). As the food system represents a significant fraction of total U.S. energy use, the food system holds considerable potential for reduced carbon impact if made the focus of campus sustainability efforts. Additionally, the existence of the American College and University President's Climate Commitment ("ACUPCC") demonstrates the importance of carbon impact among educators themselves. The document defines sustainability goals based on carbon reductions; over four hundred presidents across the nation have committed their schools to reducing their carbon footprint by signing this agreement. Notably, the Clean Air-Cool Planet Campus Carbon Calculator used by ACUPCC to perform greenhouse gas inventories covers only limited aspects of the food system, i.e., fuel use and emissions from in-kitchen preparation but not from agricultural production or distribution of food consumed in dining halls.

Colleges and universities across the country could potentially reduce energy use and CO_2 emissions from food and dining in several capacities: by (1) enacting sustainable procurement policies; (2) altering the composition of the dietary options presented in dining halls; or (3) increasing efficiency of preparation and consumption processes in dining halls. Although all of these aspects should comprise green dining hall initiatives on campuses, this study focuses primarily on sustainable procurement options. As institutions represent incredible purchasing power in the market, increased sustainable procurement by institutions holds considerable potential for influencing aspects of the entire food system. This is therefore an area in which institutions of higher education can be leaders in driving changes in market structure determining the affordability and availability of sustainable food alternatives on a wider scale.

These metrics – energy and associated carbon dioxide emissions – are thus a starting point in assessing the sustainability of local and organic options using a major Midwestern research university as a case study ("the university"). We further define our case study by examining only fresh fruits and vegetables. Through this case study, we demonstrate potential carbon emissions savings from local and organic fresh produce items. Food preservation strategies are also evaluated for carbon emissions savings within a context of limited supply of sustainable options. This study strives to demonstrate what "sustainability" might mean practically for institutional food purchasing given a single environmental metric, and provides informed analysis for those in the industry calculating the carbon impact of sustainable alternatives. Ultimately, the objective is also to point out other metrics for the food system requiring investigation that would allow more comprehensive modelling of its environmental impact.

Methodology

In this study, differences in carbon-equivalent emissions are estimated following the principles of life cycle assessment ("LCA"). Carbon-equivalent emissions are defined as the emissions from carbon dioxide, methane and nitrous oxides converted to equivalent units of carbon dioxide based on global warming potentials relative to a value of 1 carbon dioxide-equivalent (g CO_2-eq.) for carbon dioxide as defined in the 2007 IPCC assessment (IPCC 2007). While a complete LCA analysis for fruits and vegetables in the university's dining halls is beyond the scope of this study, two main energy consumption items are used to approximate the relative carbon savings for local and organic versions of these foods, (1) energy used in *fertilizer and pesticide manufacture* ("agrochemicals") and (2) energy associated with *transportation* from "farm-gate" to local distribution centres. Carbon-equivalent emissions are compared as idealized differences between systems, i.e., the energy consumption and related emissions for the differences between (1) conventional and organic and (2) conventional and local.

Emissions are estimated by analysing amounts of various fresh produce items for a representative time period (November 2007) from one campus dining hall, one of three dining halls at the university. These data are up-scaled to represent the university's total demand for fruits and vegetables in this particular cafeteria over a nine-month (academic year) period. The Resident District Manager for the university's managed services firm characterized consumption from week to week throughout the academic year as stable, and the produce list in this study as suitably representative (2007 in-person interview of Resident District Manager, concerning university dining hall statistics; unreferenced; see Table 1).

Here, energy used in the manufacture of *fertilizers and pesticides* applied at national, crop-specific average levels defines the energy consumption that differs between conventional versus organic. The carbon-equivalent emissions savings in organic food production are idealized as the potential carbon-equivalent emissions produced during the manufacture of synthetic fertilizers and pesticides applied to crops in conventional production. When indirect energy costs are taken into account, 47% of all energy use on a conventional farm is attributed to the manufacture, packaging, transport and application of agrochemicals (Helsel 1993). The remaining emissions from energy use on a conventional farm (for example, carbon

Table 1 Produce items for sample month November 2007

Food Item[a]	No. Units[b]	Unit[c]	Unit weight[d] lbs	Monthly total weight lbs/mo	Annual total weight lbs/year	Annual total weight kg/year
Apples	29	Case	38	1,102	13,224	5,998
Aubergine	6	Case	20	120	1,440	653
Bananas	43	Case	40	1,720	20,640	9,362
Beans, green	15	Case	10	150	1,800	816
Bok choi	3	Case	65	195	2,340	1,061
Broccoli	16	Case	20	320	3,840	1,742
Cabbage	3	Case	50	150	1,800	816
Cantaloupe	21	Case	42	882	10,584	4,801
Carrots	23	Var.	Var.	544	6,528	2,961
Cauliflower	16	Case	40	640	7,680	3,484
Celery	5	Case	60	300	3,600	1,633
Cucumbers	11	Case	26	286	3,432	1,557
Garlic	15	Jar	5	75	900	408
Grapefruit	7	Case	40	280	3,360	1,524
Grapes	37	Case	20	740	8,880	4,028
Honeydews	21	Case	32	672	8,064	3,658
Kiwifruit	1	Case	25	25	300	136
Lemons	2	Case	40	80	960	435
Lettuce	128	Var.	Var.	1,478	17,736	8,045
Mangoes	3	Case	26	78	936	425
Mushrooms	40	Var.	Var.	375	4,500	2,041
Onions	34	Sack	50	1,700	20,400	9,253
Onions, green	7	Case	8	56	672	305
Oranges	12	Case	40	480	5,760	2,613
Pears	4	Case	36	144	1,728	784
Peas, green	6	Case	10	60	720	327
Peppers	55	Case	25	1,375	16,500	7,484
Pineapple	61	Case	20	1,220	14,640	6,641
Potatoes	27	SK	50	1,350	16,200	7,348
Spinach	27	Case	10	270	3,240	1,470
Squash	23	Case	20	460	5,520	2,504
Strawberries	6	Case	8	48	576	261
Sweet potatoes	22	Case	40	880	10,560	4,790
Tomatoes	79	Var.	Var.	1,912	22,944	10,407
Watermelons	27	Case	60	1,620	19,440	8,818

[a,b,c]Data from ("Usage velocity report for_____Dining Commons for the period from 11/01/07 to 11/30/07" 2008)

[d]Data from (USDA AMS 2006). Var. = Variable unit weights among individual produce units; variation is accounted for in total weight

emissions related to operation of farm machinery) are assumed to be the same between conventional and organic. To arrive at kg CO_2-eq./kg crop from agrochemicals, we divide rates of agrochemical application for each crop by respective yields. Data for rates of application are taken from USDA (USDA NASS 2004a; USDA NASS, 2006a, b; USDA NASS 2007a). Yields are also predominately from USDA and supplemented when necessary (Hudson et al 2007; USDA NASS 2003;

USDA NASS 2004b; USDA NASS 2005; USDA NASS 2007b,c; USDA NASS 2008a, b, c, d). Energy used in production of agrochemicals and the a rate of CO_2-eq. emissions is calculated using values calculated based on the Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model (GREET 2009).

The methodology for calculating carbon-equivalent emissions savings in local food production differs from above. Here, energy used in *transportation* defines the energy consumption that differs between conventional versus local. Carbon-equivalent emissions savings for local are taken to be the carbon-equivalent emissions produced during longer shipping distances for food items. Data on mode and origins were collected primarily from USDA Agricultural Marketing Service "Custom Movement Reports" and supplemented when necessary (USDA AMS 2006; USDA NASS 2008a; USDA NASS 2007b, c). This approach is in contrast to previous studies of transportation of food that relied on "arrival data", a database that was discontinued in 1999 (Pirog and Benjamin 2003). Items shipped to the U.S. by boat have a second source of transportation emissions resulting from trucking from the port city to the location of the university (Los Angeles, Miami or New York is assigned to each boat shipment dependent on origin). Energy and carbon-equivalent emissions for each crop are weighted by transport mode and distances from this set of likely origins to arrival at the destination city using energy intensity and carbon-equivalent intensity conversion factors (U.S. DOE EERE 2008; Weber and Matthews 2008 respectively). These calculations are applied to three definitions of a "local" parameter: 161 km (100 mi), 322 km (200 mi) and 805 km (500 mi). Additional emissions from refrigerated trucking and rail transport are factored into the emissions intensity figure for all "truck" and "rail" shipments, including all local truck transportation. Based on a recent estimate by Tassou et al (2009), GHG emissions from "conventional diesel engine driven vapour compression refrigeration systems commonly employed in food transport refrigeration" can be 40% as high as emissions from the vehicle's engine. An additional impact of 40% greater emissions is therefore applied to truck and rail CO_2-eq. intensities respectively. Finally, energy and emissions from the local transportation schemes are subtracted from those of the conventional scheme to demonstrate net local savings.

Lastly, the authors apply these related environmental metrics to various food preservation methods for local food. Energy and carbon emissions (not carbon-equivalent emissions) are calculated for each produce item in three scenarios: canning; freezing for 6 months at $-18°$ Celsius; and cold storage for six months at $1°$ Celsius. Energy intensity figures for each process (Pimentel and Pimentel 2006; Dutilh and Kramer 2000; and Blanke and Burdick 2005 respectively) are converted to carbon emissions intensities using a national average rate of carbon emissions from generation of electricity (U.S. DOE and U.S. EPA 2000). Energy intensities for these preservation processes reflect commercial level efficiency. For each produce item, carbon emissions associated with canning, freezing and cold storage are added to carbon-equivalent emissions from truck transportation for 100 miles. These emissions are compared with carbon-equivalent emissions from

Table 2 Reference figures used in calculations for the study

Item	Energy	Reference	Emissions	Reference
Agrochemicals	*BTU/g nutrient*		*g CO_2-eq./g nutrient*	
N	45.96	GREET (2009)	2.988	GREET (2009)
P	13.36	GREET (2009)	1.036	GREET (2009)
K	8.43	GREET (2009)	0.690	GREET (2009)
Herbicide	265.50	GREET (2009)	21.641	GREET (2009)
Insecticide	309.73	GREET (2009)	25.084	GREET (2009)
Fungicide	179.87	GREET (2009)	14.563	GREET (2009)
Transportation[a,b]	*BTU/ton-mile*		*kg CO_2-eq./ton-mile*	
Air	21,976	U.S. DOE EERE (2008)	1.088	Weber and Matthews (2008), Tassou et al (2009)
Boat	511	U.S. DOE EERE (2008)	0.024	Weber and Matthews (2008), Tassou et al (2009)
Piggyback rail, unrefrigerated	325	U.S. DOE EERE (2008)	0.029	Weber and Matthews (2008), Tassou et al (2009)
Rail, refrigerated	325	U.S. DOE EERE (2008)	0.040	Weber and Matthews (2008), Tassou et al (2009)
Truck, refrigerated	3,163	U.S. DOE EERE (2008)	0.403	Weber and Matthews (2008), Tassou et al (2009)
Food preservation	*kcal/kg food*		*g CO_2/g food*	
Canning, commercial	575	Pimentel and Pimentel (2006)	0.408	U.S. DOE and U.S. EPA (2000)
Freezing, commercial	1,252	Dutilh and Kramer (2000)	0.889	U.S. DOE and U.S. EPA (2000)
Cold storage	232	Blanke and Burdick (2005)	0.165	U.S. DOE and U.S. EPA (2000)

[a]Energy intensities for transportation do not reflect refrigeration, while emissions intensities for transportation do reflect refrigeration

[b]Energy intensities for transportation reflect a short ton (2,000 lb), while emissions intensities for transportation reflect a metric ton (1,000 kg)

conventional transportation distances to demonstrate savings possible through local food that is preserved for future consumption. All reference figures used in calculations are provided (see Table 2).

In developing the above methodologies, we made a number of assumptions to simplify calculations. No local produce is considered to be organic, and no organic produce is considered to be local; however, this reflects a realistic procurement situation limited by supply and variety among sustainable produce options for schools ordering at large volume. The sum of the two metrics, i.e. local-organic produce, is considered to be an ideal situation in which averted carbon-equivalent emissions are maximized as narrowly defined in this study. Additionally, the following assumptions were made regarding each model, organic and local; accounting for these assumptions in future studies will significantly improve the estimate in modelling carbon impact from the food system.

Organic Model

We assume that (1) yields are the same between organic and conventional production, (2) direct on-farm energy inputs are the same between organic and conventional production, and (3) agricultural N_2O emissions are the same between organic and conventional. Additionally, we do not include potentially enhanced GHG mitigation from CO_2 sequestration by soil organic matter in the organic model. Quantitative incorporation of these assumptions concerning organic production into the organic GHG footprint could alter apparent organic emissions savings. To touch briefly on each of these issues: yields in organic agriculture are commonly thought to be much lower than in conventional production, reducing potential GHG savings. However, a recent review broadly comparing yields in organic and conventional production systems suggests that organic yields in developed countries are on average 92% of conventional yields, while in developing countries organic yields can actually be higher on average than those from traditional agricultural practices (Badgley 2006). N_2O emissions represent another significant contribution to the GHG footprint of agriculture. A review of 846 studies on agricultural N_2O and NO emissions suggests that fields fertilized with synthetic fertilizer can demonstrate higher emissions than those fertilized with organic fertilizer types (Bouwman and Boumans 2002). Sustainable fertilizer management with an emphasis on using composted plant residue and animal manure (a practice common in organic agriculture) is thus one method for N_2O mitigation from agricultural lands (Akiyama et al 2004; Mosier et al 1998). Finally, carbon sequestration by soil organic matter is a potentially significant sink for CO_2. As several studies suggest that carbon storage abilities of soil organic matter in sustainably managed agricultural lands might be higher than in conventionally managed agricultural lands (Drinkwater et al 1998; Komatsuzaki and Ohta 2007; Lal 2004), incorporation of CO_2 mitigation by soil organic matter into the GHG footprint of organic versus conventional agriculture likely confers an advantage in organic production.

Local Model

We do not account for extra food miles travelled at the origin or destination of produce items for either current, large scale conventional or proposed, smaller scale local food systems, i.e., more complex modelling of supply chains and distribution networks. Quantitative incorporation of this assumption concerning local production into the GHG footprint of locally produced foods could alter apparent local emissions savings. The food miles used for conventional produce are undoubtedly an underestimate, and higher resolution of data illustrating distribution networks might demonstrate increased emissions savings possible through local agriculture. However, critics of local food systems cite decreased energy efficiency in distribution schemes as inherent in a smaller scale system that utilizes more producers to supply the demand for food. Incorporation of changes in energy efficiency between large scale conventional and smaller scale local food distribution systems could also alter apparent local emissions savings.

Data

Uniformly, transportation (net savings under three definitions of a local parameter) accounts for a larger amount of energy and CO_2-eq. emissions per unit of crop than agrochemicals (savings under an organic regime) (see Table 3). Although CO_2 emissions are a derivative of energy flows, CO_2-eq. emissions are not converted directly from energy use for each crop; an independent carbon-equivalent emissions intensity is instead used. This is because fuel efficiency can differ among processes; manufacture of agrochemicals emits CO_2 at a different rate than fuel combustion in transportation. Natural gas comprises the main feedstock in the manufacture of agrochemicals, and combustion of natural gas is more efficient (emits CO_2 at a lower rate) than combustion of gasoline (GREET 2009).

CO_2 emissions are, however, calculated as a derivative of energy flows in estimating the impact from food preservation processes, based on the assumption that for electrical appliances CO_2 is emitted as a function of electricity generation. CO_2 emissions from locally sourced foods processed for preservation (canned; frozen; or stored in cold storage and distributed through refrigerated truck mode for 100 miles) are subtracted from emissions required for conventional transportation of each produce item to demonstrate savings. Overall, canning and cold storage result in CO_2 savings for almost all food items, while freezing results in CO_2 savings for few food items (see Table 3). Canning and cold storage therefore hold the greatest potential for food preservation strategies to enhance local food availability, although environmental savings must be weighed against feasibility of sustainable purchasing policies given that frozen foods might be easier to procure and prepare in-kitchen at institutions, as well as preferred by consumers for potentially better flavour and quality retention.

Discussion

Challenges to Purchasing Food Sustainably Within the UNIVERSITY Context

Sustainable purchasing by the university dining halls throughout 2007 was limited but increased in subsequent years. Very little if any local produce was purchased by the dining halls in 2007, while the organic items purchased were cherry tomatoes, broccoli and mushrooms (2008 email from Resident District Manager concerning

Table 3 Averted CO_2-eq. emissions from conventional under organic production; local production; and food preservation schemes

Food Item	Organic savings $kgCO_2/kg$	Local savings (100mi) $kgCO_2/kg$	Local savings (200mi) $kgCO_2/kg$	Local savings (500mi) $kgCO_2/kg$	Canning savings $kgCO_2/kg$	Freezing savings $kgCO_2/kg$	Cold storage savings $kgCO_2/kg$
					(local food from 100 mi)		
Garlic	0.048	0.89	0.85	0.72	0.52	0.04	0.72
Kiwifruit	0.047	0.85	0.85	0.85	0.44	−0.04	0.64
Grapes	0.056	0.83	0.79	0.67	0.46	−0.02	0.66
Pears	0.085	0.79	0.75	0.63	0.43	−0.05	0.63
Bok choi	–	0.78	0.74	0.61	0.41	−0.07	0.61
Mango	–	0.77	0.77	0.77	0.36	−0.12	0.57
Peas, green	0.038	0.75	0.71	0.59	0.39	−0.09	0.59
Strawberries	0.026	0.75	0.71	0.59	0.38	−0.09	0.59
Cauliflower	0.045	0.74	0.70	0.58	0.37	−0.11	0.58
Lettuce	0.028	0.73	0.69	0.57	0.37	−0.11	0.57
Broccoli	0.052	0.72	0.68	0.56	0.36	−0.12	0.56
Spinach	0.043	0.72	0.68	0.56	0.35	−0.13	0.55
Celery	0.018	0.70	0.66	0.54	0.34	−0.14	0.54
Onions, green	–	0.70	0.66	0.54	0.33	−0.14	0.54
Apples	0.054	0.66	0.62	0.50	0.30	−0.18	0.50
Bananas	–	0.66	0.66	0.66	0.26	−0.22	0.46
Squash	0.039	0.65	0.61	0.49	0.28	−0.20	0.48
Peppers, bell	0.046	0.64	0.60	0.48	0.28	−0.20	0.48
Carrots	0.026	0.64	0.60	0.48	0.28	−0.20	0.48
Pineapple	–	0.63	0.63	0.63	0.23	−0.25	0.43
Cantaloupes	0.027	0.63	0.59	0.47	0.26	−0.22	0.47
Honeydews	0.012	0.59	0.55	0.43	0.22	−0.26	0.43
Aubergine	0.055	0.58	0.54	0.42	0.22	−0.26	0.42
Tomatoes	0.047	0.55	0.51	0.39	0.19	−0.29	0.39
Onions	0.019	0.55	0.51	0.39	0.18	−0.29	0.39
Cucumbers	0.030	0.53	0.49	0.36	0.16	−0.32	0.36
Mushrooms	–	0.52	0.48	0.36	0.15	−0.32	0.36
Beans, green	0.063	0.46	0.42	0.29	0.09	−0.39	0.29
Watermelons	0.022	0.45	0.41	0.29	0.09	−0.39	0.29
Grapefruit	0.047	0.45	0.45	0.45	0.04	−0.44	0.25
Lemons	0.052	0.44	0.44	0.44	0.03	−0.45	0.23
Potatoes	0.027	0.42	0.38	0.25	0.05	−0.43	0.25
Oranges	0.058	0.41	0.41	0.41	0.00	−0.48	0.21
Cabbage	0.022	0.40	0.36	0.24	0.04	−0.44	0.24
Sweet potato	–	0.29	0.25	0.13	−0.08	−0.56	0.12

Note: Local "savings" for bananas, mango, oranges, grapefruit, kiwifruit and lemons are simply emissions from conventional transportation of these products, since they are unable to be produced locally

average Autumn 2007 quantities of sustainable produce in dining hall; unreferenced). For Autumn 2008, the university purchased sprouts, aubergines, squash, sweet corn and apples locally (2008 phone interview with Resident District Manager concerning local produce in dining halls; unreferenced). Procuring local produce was found to be extremely subject to availability through produce suppliers contracted by the university's managed services firm. Conversely, the organic produce supplier used by the university dining halls can reliably supply organic versions of most produce items in the list throughout most of the school year, although cost rather than availability for organic produce could be the prohibitive factor (demonstrated by the online catalogue of the Midwestern organic produce supplier).

As cost can be prohibitive, it is an important consideration within the institutional context when purchasing sustainably according to directives. Organic food was found to entail a significant price premium for the three items purchased in Autumn 2007. Organic produce was therefore a budgetary obstacle for the university as a sustainable purchasing directive. Local food as the other sustainable option, however, was found to entail little to no price premium, indicating that it might present less of a budgetary challenge for university dining halls to purchase (2008 email from Resident District Manager, concerning likely price of local produce through produce supplier; unreferenced).

The university is one among many institutions currently facing obstacles that hinder local food procurement. Larger challenges within the food system are twofold: insufficient volume for purchase and limitation of supply from seasonality. These obstacles are recognized as top challenges by college and university dining hall officials characterizing dynamics of individual sustainable purchasing initiatives in a survey from the Community Food Security Coalition (CFSC 2008). Concern for how much and when institutions can purchase local food is important because apparent carbon savings from local versions of produce items might be reduced if availability of local food is ultimately limited. Despite a large amount of agricultural land in the Midwestern states surrounding the university, food crops are not extensively produced commercially. Therefore, even when climate and environment permit seasonal production of food crops, a large enough volume of particular local produce items are often not available for purchase to satisfy amounts and varieties sought by the dining halls. In addition, the Resident District Manager estimated that local produce is generally only available for purchase for four to six weeks on each end of the university school year, i.e., October to November and May to June (personal communication, 2008; unreferenced).

Comparison of yields for selected crops grown across the United States illustrates both of these challenges in sourcing locally. Yields are presented for crops that are produced "locally," i.e., crops with yields from states generally considered "local" and falling within the furthest 500-mile definition of the local parameter. (See Table 4). Recent USDA crop summaries list these yields, calculated by dividing total production by total acreage. Average national and California yields are presented to provide comparison with local yields. In many cases, average yields (particularly for fruits) are lower in Midwestern states than average national and California yields. These seeming limitations of local food production point to commonly cited challenges of cultivating a local food system in a temperate region.

Table 4 National, California and local yields for selected crops, 2005

	U.S. Average lb/acre	CA lb/ acre	IA lb/ acre	IL lb/ acre	IN lb/ acre	KY lbs/ acre	MI lb/ acre	MO lb/ acre	MN lb/ acre	OH lb/ acre	WI lb/ acre
Apples	21,800	14,800	1,310	12,300	12,500	6,400	19,000	12,000	9,170	13,600	8,970
Beans, Green	6,600	9,000					5,500				
Cabbage	33,700	35,000		31,500			36,000			18,000	15,000
Cantaloupe	23,900	25,500			15,500						
Carrots	31,600	31,000					36,000				
Celery	69,400	70,500					57,500				
Cucumbers	17,800	21,500					18,000				
Grapes	17,220	17,400					14,460	6,500		7,720	
Onions	46,600	40,000					26,000				33,000
Pears	29,000	25,200					5,000				
Peppers, bell	27,900	37,000					28,000			22,000	
Potatoes	40,300	39,500		38,000	35,000		32,500	34,000	41,000	24,000	41,000
Squash, summer	16,300	22,000					22,000			20,500	
Strawberries	45,100	60,000					5,200			5,300	5,100
Tomatoes	30,000	28,000			15,000		22,000			32,500	
Watermelon	29,900	49,000			38,000			27,500			

Note: Yields from (USDA NASS 2006c; USDA NASS 2007b and USDA NASS 2008d)

Ultimately, as food service officials at colleges and universities across the country create greater demand for local produce options for school dining halls, these institutions could force a change away from the limited supply and lack of infrastructure for purchasing local. For the university specifically, the university's large scale national produce supplier recently rolled out a local purchasing programme which offers reliable local produce options by contracting with local growers to ensure quality, supply and variety for university food outlets ("Lower Lakes: Fresh From Our Local Farmers" 2009). The Resident District Manager expressed that the university is committed to purchasing greater quantities of local fruits and vegetables throughout 2009 and beyond, when quality, quantity and cost permit (personal communication, 2009; unreferenced).

Overcoming Challenges to Purchasing Food Sustainably Within the University Context

The regional growing season coincides with the first and last four to six weeks of the university school year, making it nearly impossible for the university to source fresh, local produce throughout the entire school year. In this case, strategies for addressing seasonality limitations which would extend energy and emissions savings throughout the school year should be considered. Institutions can address seasonality by introducing more flexibility into procurement regimes. Flexibility to work within the local food context can be introduced through two key strategies: (1) modifying composition of the fruit and vegetable portion of the diet during months of limited fresh produce options to incorporate local, seasonal items that, for example, are cultivated through passive greenhouses (i.e., leafy greens) and (2) purchasing produce preserved during its season of production that will allow "out-of-season" consumption.

Here we focus solely on preserved food for out-of-season consumption. Food preservation or storage could be utilized at multiple points in the food supply chain: through the farmer or producer; through the larger-scale distributor; or through the university. Although the university food staff generally possesses extensive food handling experience, the Resident District Manager characterized food preservation processes (i.e., canning, freezing or keeping in cold storage) as unlikely to be implemented at the university level (personal communication, 2009; unreferenced). Required facilities and time for processing along with costs that such a regime might impose make such a strategy at the university level currently unrealistic. Instead, the Resident District Manager suggested that food preservation strategies would be easier to incorporate into the university's purchasing regime if implemented earlier in the supply chain, either as an initiative through the large scale produce supplier, or as an initiative by individual growers developing value-added products for sale. In fact, the Resident District manager in the same interview recalled purchasing frozen green beans from Michigan that had been processed at the farm level (personal communication, 2009; unreferenced).

Implementing broader scale food preservation strategies at any point in the supply chain involves costs and structural challenges unique to each point, and the logistics of any such programme would require further consideration on a case-by-case basis. One case study of successful implementation of large scale shift in purchasing to local produce is the University of Northern Iowa's ("UNI") Local Food Project. The project distributes food from 25 farmers to 10 different institutions, and at the UNI campus, food is processed at a central kitchen and then distributed to the other kitchens around the campus (Markley and Kalb 2005). Centralized processing facilities in this case study reflect the Resident District Manager's concern for the ability of individual campus kitchens to process produce items.

The data produced in this study can be used to design purchasing policies for the university that take into account relative environmental savings resulting from a variety of procurement options—organic; local in-season; and local out-of-season (i.e., preserved). A sample set of local purchasing goals might include the following policy choices, taking into account (1) carbon emissions savings of each item (Table 3), (2) items which are listed as available for at least part of the year in marketing documents from the university's large scale produce supplier (e.g., "Lower Lakes: fresh from our local farmers"), and (3) produce amounts purchased by the university (Table 1):

Bell peppers for August and September (total savings for this action of 754 kg CO_2)

Broccoli in October (99 kg CO_2)

Carrots in October and November (297 kg CO_2)

Cabbage in November and December (49 kg CO_2)

Onions November through March (1,970 kg CO_2)

Fresh local food in this calculation is assumed to come from the 200-mile definition of the parameter. Hypothetically, processed food might be an option in the future if the university expresses interest in sourcing (1) canned local produce items, (2) frozen local produce items or (3) local produce items kept in cold storage during the winter. In this case, the following can be added to these sample recommendations:

C*anned tomatoes* October through June (total savings for this action of 1,461 kg CO_2)

A*pples from cold storage* October through June (2,248 kg CO_2)

If these sample recommendations for fresh-local and processed-local food items were to be instituted at the university, the total carbon emissions savings resulting from implementation would be *6878 kg* CO_2. The Resident District Manager at the university provided the total number of transactions for the year at the dining hall (13,682 transactions; email communication, 2009; unreferenced). Assuming the same fruit and vegetable content in each meal, emissions savings can then be expressed as emissions savings per meal, perhaps a more useful metric for college and university food service officials. With the savings from the above recommendations, the total emissions savings per meal would be *0.503 kg* CO_2 *savings/meal*.

Finally, beyond simply procuring local or organic alternatives for what is currently eaten in the dining halls, larger carbon-equivalent emissions savings may come from addressing changes within the composition of the diet (Eshel and Martin 2006; Eshel and Martin 2009). The type of food consumed (e.g., meat-based versus plant-based) can yield a significant contribution to dietary carbon footprint (Eshel and Martin 2006; Eshel and Martin 2009). In fact, composition of diet has been shown to have a more significant energy-related GHG emissions impact than the distance food has been shipped (Weber and Matthews 2008). Therefore, greater GHG emissions savings might be possible through reduced meat consumption than through local and organic production of fresh produce. Reduced overall meat consumption through "meatless meals" can constitute an easy and cost-effective GHG emissions reductions strategy for college and university dining halls to implement. The university already offers daily meatless choices for vegetarians and vegans in its dining halls; promoting a "meatless meal", for example, once a week might actually lead to budgetary savings while demonstrating significant environmental savings as well. Such a programme would not mandate removing dining hall meal options containing meat, but would highlight vegetarian or vegan options and encourage students to choose these meals instead. This idea is already being instituted in school dining halls and cafeterias across the country; Johns Hopkins Bloomberg School of Public Health facilitates a nation-wide "Meatless Monday" campaign providing a toolkit for implementation by food service providers. While this particular campaign is focused solely on nutrition education and awareness, a similar model could be used to accomplish a number of goals, not only improving nutrition, but also reducing environmental impact.

Conclusions and Metrics Beyond Energy and GHG Emissions

This study develops a simple model for quantifying energy and GHG emissions associated with local and organic fresh produce *relative to* conventional production as a first step in providing food service officials at colleges and universities with better information to design effective sustainable purchasing programs. Key findings of the study show that based only on eliminating agrochemicals and reducing transportation, both organic and local food production have the potential to reduce greenhouse gas emissions relative to conventional production. A sample set of purchasing recommendations involving fresh-local and preserved-local produce resulted in noticeable savings. Based on previous work, the study also acknowledges the role that altering dietary composition (i.e., increasing plant-based versus meat-based portions of the diet) can play in reducing the institutional GHG footprint, as a complement to purchasing local and/or organic alternatives of produce items. Additionally, the study acknowledges that local food production presents unique challenges for institutional food procurement policy and that availability and supply of local produce is highly dependent upon localized climate, ecology and supply chains. Institutional food procurement policy must therefore be tailored to the institution in question. Finally, to increase energy use and carbon emissions savings possible through local food procurement, food storage strategies might be utilized to extend seasonality and availability of foods through the year; however, feasibility of instituting food storage processes and protocols within the institutional context needs further evaluation.

Ultimately, more refined modelling of energy and GHG emissions associated with these food items would likely contribute greatly to our understanding of this particular environmental impact. However, many other impacts contribute to the overall environmental footprint of the foods we eat, and metrics beyond energy and GHG emissions for the food system need to be better developed and understood. Although more knowledge is needed around the issue, by engaging in sustainable food purchasing institutions likely enhance a wide range of environmental savings not captured within the narrow evaluation of energy and GHG emissions performed in this study, for example, improvements in air and water quality, greater relative building of soils and increased biodiversity.

Not dealt with extensively in this study due to lack of data, banana cultivation presents a useful anecdotal example demonstrating both the need for more metrics and other environmental advantages of sustainable (specifically organic) production beyond decreased energy intensity and CO_2 emissions. In a review of world agricultural practices, Clay (2004) finds that "bananas produced for international trade are the most pesticide-intensive of the major tropical food crops." Clay (2004) also finds that conventional bananas grown for export are also particularly fertilizer-intensive, and that fertilizers are rarely applied with site-specific requirements taken into consideration. Additionally, the method of irrigation associated with this cultivation regime for bananas intensifies the resulting environmental degradation through water runoff. Although organic production of bananas likely does lead to CO_2 emissions reduction or energy savings through reduced use of agrochemical inputs, organic production might also reduce other significant ecological impacts from conventional banana cultivation, such as water runoff and resulting watershed impacts; long-term contamination of soils and rates of tropical deforestation (due to differences in how long banana plantations remain productive under different management regimes).

Pesticide exposure, in particular, constitutes an insidious set of impacts all along the production chain. Regardless of the type that occurs, exposure can have severe consequences, be it to employees in chemical production plants, to farm workers, to consumers purchasing produce in a supermarket or to the ecosystem more widely. Although large-scale, long-term studies documenting the impacts from pesticide exposure within multiple dimensions are scarce, a growing literature in this field is beginning to demonstrate the negative impacts that pesticide exposure is thought to have: long and short-term health effects in farm workers including reported links to cancer (Calvert et al 2008; McCauley et al 2006; Mobed et al 1992); persistence of pesticides in foods that consumers buy and eat (Environmental Working Group 2009; PAN U.K. 2006; U.K. Food Standards Agency 2008); and among other environmental impacts, effects on biodiversity and a decrease in abundance and number of species within particular ecosystems (Schafer et al 2007; Steenwerth et al 2005). A production regime that eliminates this chain of impacts, as well as the GHG emissions from their production, by eliminating the use of these harmful chemicals altogether might constitute a more responsible method of food production, and mandates continued vigorous investigation in future research.

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Chapter 21
Graduate Studies of Global Change at the University of Latvia

Arnolds Ubelis, Janis Abolins, Dina Berzina, Janis Blahins, and Gunars Bajars

Abstract In 2008 the University of Latvia (UL) completed an 18-month project of innovation – design, preparation and pilot-test of a 4-semester programme of trans-disciplinary graduate studies in "science, global change, and technologies for sustainable development" based on the experience the project team had acquired during 1997–2006 endorsing studies in "physics and technologies for sustainable development" and organizing two international conferences on "integrative approaches towards sustainability".

Within the project activities 25 members from faculties of natural sciences of the UL prepared and tested innovative courses of a 2 semester pilot programme comprising 4 modules, the audience being a multidisciplinary group of graduates and postgraduates. The 4 modules included geophysics, biophysics, environmental physics, chemistry, global change, closed production cycles and other technologies, corporate responsibility, and research methods. The paper provides details of information and knowledge on climate change considered within the programme, experience acquired during the project activities, and future prospects including the mission of the project team in raising the general public's awareness about the science of climate change.

For the long-term efforts, the project team was awarded the national prize of ENERGY GLOBE 2007 on sustainability in the category "YOUTH" by the EU Parliament in Brussels on 26 May 2008.

Keywords Closed production cycles · Corporate responsibility · Global change · Teaching sustainability · Trans-disciplinary science

Introduction

"The University Charter for Sustainable Development" (Copernicus 1997), launched in 1994 in Geneva by The Association of European Universities within the COPERNICUS* programme of Inter-University Cooperation on the

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Environment and signed by the Rector of the University of Latvia among others, inspired the project team to start research training and education activities in education for sustainable development. Among others, Article 5 of the Charter – "Interdisciplinary" advises that ..."universities shall encourage interdisciplinary and collaborative education and research programmes related to sustainable development as part of the institution's central mission. Universities shall also seek to overcome competitive instincts between disciplines and departments...". Evidently the Charter had a great impact on the academic community and was a stimulus to the European Council to design and approve the milestone framework directive on integrated prevention and control of pollution in 1996 (Council Directive 96/61/EC), tracking EU legislation on integrated approaches towards sustainable development.

The team raised its first knowledge transfer pioneering the approach by a project of graduate studies in "physics and technologies for sustainable development" in 1997. It is worth noting that relevant EU political documents considering technologies for sustainable development emerged only in the years 2002–2004 (COM (2002) 122, COM (2004) 38). The project was continued until 2005 under a step-by-step decrease in financing and lack of conceptual support by decision makers in the administration of the University and in the government structures of financing. Quite the reverse, the project was treated like an unacceptable competitor to so-called "classical" green teaching programmes mostly on the background of social sciences. Nevertheless, the project team supported by the faculty and engaging about 10 enthusiastic professors and lecturers worked hard to keep the mission of the project alive by recruiting students for graduate studies in "physics and technologies for sustainable development". As a result of the 8-year efforts, 30 of the 40 students involved in the full-time programme were awarded the MS degree, of which 5 went on to a postgraduate study. 10 dropped out at various stages.

Conclusions drawn from the 8 year experience can be summarised as follows:

- The programme is attractive for students of various ages;
- Unfortunately, it does not seem to be attractive to sources of national funding;
- The programme provides important retraining possibilities, including life-long learning needs – some students came to get a second MSc degree;
- Challenging, but not easy for everybody. Most students were working, only a few were able to complete the studies in two academic years, about 30% dropped out or took only a part of the programme;
- In general, the new dimension towards the needs of sustainable development in teaching physics should bring a rewarding impact on the general attitude towards the problems of global and climate change and issues of sustainable development, facilitating the research on environmentally sound technologies and affecting high school education through teaching science.

While implementing the project, two large scale conferences on integrated approaches towards sustainable development financed by FP5 and FP6 of EU have been organized: 1st international conference "Integrative Approaches towards

Sustainability" – Baltic Sea Region taking the lead "TOWARDS" 26–29 March 2003, Jurmala, Latvia, FP5 Contract Nr. HPCFCT-CT-2002-00102 and 2nd International Conference "Integrative Approaches towards Sustainability" – Baltic Sea Region sharing knowledge internally, across Europe, and world-wide "SHARING", 11–14 May 2005, Jurmala, Latvia, FP6 Contract Nr. GOCE 009244, http://home.lanet.lv/~asi/conference.htm. The 3rd International Conference "Integrative Approaches towards Sustainability" – "KNOWLEDGE" project is pending and will be targeted to linkage of sustainable development and knowledge society. Two books on the conference proceedings have been issued (Leal Filho and Ubelis 2004; Leal Filho et al 2006).

The project laid the foundation for the next more comprehensive step and that occurred as a nice coincidence of the new project supported by the European Social Fund (ESF) being raised late in 2005 when the United Nations Decade on Education for Sustainable Development (2005–2015) started across the world (UN Resolution 57/254 2002).

New Transdisciplinary Graduate Programme

The project aimed towards innovations in MSc studies in science and had the goal of preparing curricula for a graduate programme in "science, global change, and technologies for sustainable development" and was financed by the EU Structural Funds in Latvia (national reg. no. 2006/0253/VPD1/ESF/PIAA/06/APK/3.2.3.2./0089/0063; LU reg. no. S46-ESS57-109). The project was started late in 2006 and finished in summer 2008 mobilising academic staff (more than 10 full and assistant professors) of the faculties of natural sciences at the University of Latvia and researchers from the Institute of Atomic Physics and Spectroscopy and the Institute of Solid State Physics to develop courses for the new trans-disciplinary programme of graduate studies in science, including an e-version and an English version. The project, having a relevant work package and fellowships, allowed recruitment of students for a pilot course to test the newly designed courses and immediate dissemination and use of knowledge in training a new type of professional. The project was very challenging and this article shares the experience and results gained.

Besides direct tasks of innovation in teaching science at the tertiary level, the project had publicity tasks and was used as an excellent comprehensive opportunity to inform, communicate and educate a broad audience of university students, professors, researchers, and the public on issues of global changes and climate change and their dangerous consequences now and in the near future. The audience of schoolchildren and general public were also approached by numerous lectures by the project experts, leaflets, and science café events.

The previous expertise of the project team and the University of Latvia, the concept, the approach of the project, and expected developments towards the project have been presented at two international conferences:

1. Arnolds Ubelis, Teaching Physics and Sustainability, World Conference on Physics and Sustainable Development, Durban, South Africa, 31 October-2 November 2005;
2. Arnolds Ubelis, Janis Abolins, Dina Berzina. Teaching Physics and Sustainability 4th World Environment Education Congress Durban, South Africa, 1–7 July 2007.

Short Insight into Expected Labour Market

While designing the project proposal and during operation of the project efforts were made to clarify the current and long-term labour market demands for professionals with the proposed tertiary training. Emergence of the single European Research Area (ERA) (COM(2007), p. 161) and, accordingly, formation of single labour market in the European RTD sector (Report of the ERA Expert Group 2008) the national and EU (A European partnership to improve the attractiveness of RTD careers and the conditions for mobility of researchers in Europe 2009) demands were evaluated.

At a national level, urgent requirements in several domains of public and private sectors of the economy were identified:

First – there are limited possibilities to attract students by national leaders in a number of directions of fundamental and applied science and technologies:

- “Photovoltaics” and related problems;
- “Fuel cells” and hydrogen energetics;
- Nuclear energy;
- Problems of biomass conversion;
- “Remote sensing and satellite ranging” in the context of atmospheric research and satellite technologies;
- Polluted atmosphere, air quality and problems of public health;
- Modelling the state of environment, the tasks of local and global monitoring;

Second – there is an obvious demand by the national and EU economic and management institutions for professionals with a background education in science who understand existing and expected problems created by global change in the context of particular fields of science and technology.

Third – there is an additional national obligation requiring a professional response to a proposed partnership with the Nordic countries concerning sustainable development and healthy environment in the Baltic region.

To join the excellent partnership of the NORDIC countries in the market of environmental technologies, Latvia must promote innovative technology transfer, facilitate innovative methods of training the research skills of students and develop trans-disciplinary graduate programmes based on science to meet the demand for well-trained professionals able to participate in research of global change and advancement of technologies for sustainable development.

Apart from urgent short-term demands, the programme will also be needed in the EU labour market as seen from various political documents at the EU level, and therefore the concept of the proposed innovative teaching programme complies with the latest policies announced by EU.

The Project in Details

The Project "Innovation in MSc studies in physics and natural sciences – science, global change and technologies for sustainable development": November 2006 – August 2008 has mobilised the teaching and research staff of the University of Latvia to design and develop a new trans-disciplinary programme of graduate studies in science, including electronic and English versions to invite students from abroad. The project was implemented based on the infrastructure of two research institutes – Institute of Solid State Physics and Institute of Atomic Physics and Spectroscopy with support from the Faculty of Physics and Mathematics, Faculty of Chemistry and Faculty of Earth Sciences and Geography.

The team prepared graduate lecture courses with 44 credits for the proposed two year programme "Science, global change, and technologies for sustainable development". In September of the academic year 2007/2008 the project started pilot studies with 25 recruited graduate students of diverse BSc or MSc backgrounds: physics, chemistry, mathematics, engineering, and computer science.

The first year included theoretical studies. The project offered fellowships to students and resources for four week research training visits abroad. The pilot course was supposed to have a "win-win" outcome. Students obtained knowledge and teachers tested the newly developed courses.

The programme for pilot studies consisted of 4 thematic modules:

- Module of science comprised geophysics, biophysics, environmental physics, green chemistry, and atmosphere science;
- Module of technologies offered courses on renewable energy technologies, closed production cycles, nanotechnologies and monitoring including space technologies;
- Module of corporate responsibility contained a course on business and ethics, a course on marketing new technologies, basics of EU environmental law, environmental management, and ISO-14000 series;
- The module of research methods was supposed to provide basic and specific training in labs and modelling methods.

Students of the pilot course who covered the first year of studies were invited to continue their efforts for the second year involving research training and writing a thesis in other institutions in Latvia or abroad. During the first year the students were able to collect a total of at least 44 credits. The planned full graduate programme including thesis demanded study efforts for 80 more credits. 10 pilot course students finished the full first year programme, but 15 succeeded in obtaining credits in particular courses. Among them, the majority already had an MSc degree in their background disciplines and 2 were already PhD students. To date, 2 graduates of the pilot course finalising their research training efforts are going to continue with PhD studies.

In cooperation with experienced teams in the field at the Institute of Environmental Physics of the University of Bremen, School of Environmental Science of the University of East Anglia and the Baltic University Programme of the Uppsala University it was planned within the project activities to have visiting professors come to Riga to contribute to the pilot programme. Additionally, a visiting professor from the University of Bern gave her lecture as well.

The members of the group of pilot studies prove that the programme is attractive and needed in practice. The major part had a serious working experience. They still had to earn their living taking the challenge to participate in the full-time studies for two semesters: September – December with final examinations in January and February 15 – June 20 with final examinations late in June. Lectures were scheduled on Tuesdays, Wednesdays and Thursdays from 16.00 to 20.00 and from 9.00 to 17.00 on Saturdays. The pilot course was organized in several functional modules with clearly defined objectives and aims for each of the functional modules ensuring continuity and diversity in knowledge delivery and keeping attractiveness and intensity of studies high. The courses selected for each functional module were delivered within the period of 1–2 months. Apart from lectures, there were also interactive seminars and students were invited to pass tests. The guest lectures were flexibly planned using additional hours during the week or substituting the regular lectures. The schedule of the pilot programme is given in Fig. 1. Beside others, the advantage of selected mode of delivery was also the possibility for students to select single modules or courses and cover them quickly.

Functional module and Course	**Part**	**Credits**	**S1**	**S2**	**S3**	**S4**
Module I, Autumn		*7.5*				
01.09.2007. – 15.10.2007. Concludes with passing course exams in accordance with requirements Goals: ➢ By 4 introductory lectures to provide an overview raising professional interest in sustainable development and motivation to study the science of global change ➢ Refresh the necessary chapters of mathematics and physics and, in the context of natural history, extend awareness of dynamics of the global processes and of the corporate response of science providing explanation of current processes and forecasts of the expected in a number of other courses						
Global Change – Aspects of Science: 4 Introductory talks	**A**		0.5			
Research methods II – Physics for studies in "Science of global change and sustainable technologies"	**A**		2			

Fig. 1 (Continued)

Functional module and Course	Part	Credits	S1	S2	S3	S4
Research Methods I – Basics of calculus for studies in global change and sustainable technologies	**B**		2			
Natural History	**B**		2			
Ethics of sustainability, business and technology development	**C**		1			
Module II, Autumn		***6.5***				
15.10.2007. – 15.11.2007. Concludes with course exams Goals: ➤ To show the importance of science and its mission of understanding the planetary processes by teaching the basics of geophysics ➤ Continue the course of global change to show the advantage of space born observation systems ➤ Introduce the concept of corporate responsibility and ethical principles of economic activity						
Global Change – Aspects of Science	**A**		1.5			
Geophysics (Part I)	**A**		2			
Space-born remote sensing equipment	**B**		2			
Ethics of sustainability, business, and technological development	**C**		1			
Module III, Autumn		***6***				
15.11.2007. – 30.12.2007. Concludes with course exams. The last part of autumn semester before final exams in January 2008 Goals: ➤ Complete the basic research training, provide the basics of green chemistry and intellectual property rights						
Green chemistry	**B**		2			
Research methods III – Selected laboratory classes and data processing in physics and chemistry	**B**		2			
Patents and patenting	**C**		2			
Module IV, Spring		***6***				
16.02.2008. – 20.03.2008. Concludes with course exams Goals: ➤ Complete the course of geophysics and teach the crucial contribution of energy consumption to climate change and the essentials of advancement of alternative technologies ➤ Introduce the legislative framework of corporate responsibility						
Geophysics (Part II)	**A**			2		
Sources of energy and environmental impacts of energy consumption	**B**			2		
Evolution of technologies and environmental legislation – legislative acts of protection of the atmosphere	**C**			2		

Fig. 1 (Continued)

Functional module and Course	Part	Credits	S1	S2	S3	S4
Module V, Spring		***6***				
24.03.2008. – 24.04.2008. Concludes with course exams Goals: ➢ Introducing the research of and necessity for closed technological cycles ➢ Apprehension and development to closing life cycles of nano-technologies ➢ Introduction to modern international standards and practice of conservation of natural systems						
Zero emissions technological systems	**B**			2		
Environmental management systems, international environmental standards	**B**			2		
Nanotechnologies and risk assessment in the life-cycle of nanotechnology-based products	**B**			2		
Module VI, Spring		***8.5***				
26.04.2008. – 31.05.2008. Concludes with course exams Goals: ➢ To reveal importance of physics in understanding biological processes ➢ Concepts of spectroscopy in research of atmosphere and atmospheric hazards ➢ Demonstration of the benefits capability of modelling						
Biophysics	**A**			4		
Sustainable materials and technologies	**A**			0.5		
Spectrometry and photochemistry of the atmosphere	**B**			2		
Research methods IV – Modelling and computer simulation for environmental management	**B**			2		
Module VII, Spring		***3.5***				
1.06.2008. – 20.06.2008. Concludes with course exams Goals: ➢ Continuing the course of technologies and materials for sustainable development accenting the nano-scale achievements ➢ Introducing the concept of the European research and innovation area, new technology marketing and capabilities of foresight						
Sustainable materials and technologies	**A**			1.5		
Innovations and marketing of advanced technologies	**C**			2		

Fig. 1 Functional Model

Innovative Aspects

Since natural sciences are the most important component of the basis for development of new technologies, it is logical to put the programmes and teaching accents on global change and technologies for sustainable development. The project brought innovative aspects to the current traditional teaching of science at the University of Latvia by broadening the national scale and by designing several specific and advanced courses as well.

Main Results and Conclusions

The final structure of the programme for graduate studies in "science, global change and technologies for sustainable development" is presented in Fig. 2.

Conclusions

The project is supposed to have short-term and long-term "win-win" outcomes. About 25 teaching and research staff members were involved preparing new courses as well as upgrading their knowledge related to specific topics and

Module / Course		Credits	S1	S2	S3	S4
1 Module of Science: Contribution of science to education for sustainable development		**16**				
Global Change – Aspects of Science	**A**		2			
Geophysics (Part I)	**A**		2			
Biophysics	**A**			4		
Natural History	**B**		2			
Green chemistry	**B**		2			
Spectrometry and photochemistry of the atmosphere	**B**			2		
Dynamics of atmosphere and atmospheric pollution - optional	**B**			2		
2 Module of Technology: Future technologies, development, needs, requirements, prerequisites, and responsibility		**10**				
Sustainable materials and technologies	**A**			2		
Space-born remote sensing equipment	**B**		2			
Zero emission technological systems	**B**			2		
Nanotechnologies, and risk assessment in the life-cycle of nanotechnology-based products	**B**			2		
Nanotechnologies, and risk assessment in the life-cycle of nanotechnology-based products	**B**			2		
3 Module of Corporate Responsibility: Corporate responsibility, trans-disciplinary holistic approach – the way toward implementation of the concept of sustainable development on local and global scale		**10**				
Environmental management systems, international environmental standards	**B**			2		
Sources of energy and their environmental impacts	**B**			2		
Science of patenting (study of patenting)	**C**		2			
Innovations and marketing of advanced technologies	**C**			2		
Evolution of technologies and environmental legislation – legislative acts at air protection sphere	**C**			2		

Fig. 2 (Continued)

Module/Course		Credits	S1	S2	S3	S4
4 Module of Research Methods: providing basic and specific training		**8**				
Research methods II – Physics for studies in "Science of global change and sustainable technologies"	**A**		2			
Research Methods I – Basics of calculus for studies in global change and sustainable technologies	**B**		2			
Research methods III – Selected laboratory classes and data processing in physics and chemistry	**B**		2			
Research methods IV – Computer modelling for environmental management needs	**B**			2		
Practical training, MSc Paper						
Research training	**A**				10	
Advanced laboratory classes in physics	**A**				6	
MSc Paper	**A**					20
Concise summary						
Total Credits		**80**	**18**	**26**	**16**	**20**
A Credits		**28**	6	6	16	
B Credits		**26**	10	16		
C Credits		**6**	2	4		
MSc Paper		**20**				20

Fig. 2 Structure of the programme for graduate studies

problems of the project. A strong initial group of 25 students were trained during the project. The main economical outcome – mobilisation of human resources for advancement of sustainable development of Latvia**.**

The programme developed within the project and the experience of the team can be easily used by other universities with a long-term perspective. The project team is planning to open an extended programme for foreign students. Participants of the project (experts and audience alike) have obtained knowledge on the basis of which they can rethink the principles of individual activities towards advanced approaches and reasonable patterns of consumption.

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