Lessons Learned for Decision-Makers During a 5-Year Research Period on Sustainability Problems at the Galileo University in Guatemala

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Abstract

The findings outlined in this paper have two core audiences in mind. The first are decision-makers with interest in sustainable development, and who can use the information to shape policy. The second are sustainable universities that may provide the needed research for the monitoring and evaluation on what is proposed. Between 2009 and 2013, Galileo University administered Renewable Energy and Climate Change sample surveys to entrepreneurs, university personnel, government officers, and civil society leaders in Guatemala. Qualitative and quantitative analysis was then conducted by the Galileo University on the collected survey data for this time frame. The analysis revealed weaknesses, that if not addressed, are capable of halting sustainability efforts in all Guatemalan sectors—academic, private, government, and the general public. Specifically, the research identified five sustainable development gaps which can serve, not only as important and foundational lessons for all surveyed participants, but also addressed by academic institutions and decision-makers to formulate appropriate actions. These gaps are the following:

(1) The divorce/disconnect between research and teaching;
(2) The lack of balance between specialized fields and multidisciplinary perspectives;
(3) The absence of internal (within the university) and external (larger society) alignment in addressing sustainability problems;
(4) Deficits in coordination within and between public, private, NGOs, and academic organizations;

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(5) And finally, the lack of time linkages (short-, medium-, and long-term) which will postpone decisions until the end of the century or later and ultimately, paralyze decision-makers.

All these sectors—academic, private, government, and the general public—should strengthen their own capabilities by making respective internal changes to address these gaps and by forming "smart" strategic alliances. The implementation of "Quadruple and Quintuple Helix Innovation Models," involving decision-makers, applied to these weaknesses appear to be the best policy decisions. These models emphasize collaborations, alliances, and networks. Then and only then, can these sectors address the challenges ahead: the academic sector would strengthen their offer to the larger society and avoid the consolidation of "clusters," which mean confinements; entrepreneurs will be able to embrace their social responsibility; governments accept networks and horizontal relationships, while civil society may adopt common objectives moderating their dispersion of activities and resources. Universities will then become more sustainable and larger society more resilient.

Keywords
Sustainable development · Renewable energy · Climate change · Networks

1 Introduction

From January 2009 to December 2013, a multidisciplinary team from the Sustainable Development Institute (IDS by its name in Spanish) of Galileo University in Guatemala was able to carry out a series of investigations, co-sponsored by the Alpha III Program of the European Union. Two different projects were carried out: The so-called "Joint European-Latin American Universities Renewable Energy Project" (JELARE) and the "Network of Climate Change Technology Transfer Centre in Europe and Latin America," (CELA), (Consorcio del Proyecto JELARE 2011 and Consorcio del Proyecto CELA 2012; Network of Climate Change Technology Transfer Centre in Europe and Latin America CELA 2012). Despite having different themes, the two projects and the observed results have a close link due to the impact of fossil fuels in the generation and impacts of greenhouse effects, GHE, due to emissions (Amaro 2012, 2014; Amaro et al. 2012). Carbon dioxide, a by-product, of burning fossil fuels, represents around two-thirds of the gases that may cause extraordinary climate changes on earth (Castellanos and Guerra 2010). The Intergovernmental Panel on Climate Change, IPCC (2007, 2013), warns that if the human component that mainly generates this phenomenon is not presently regulated, the rise in temperature left to its own evolution in time would cause huge catastrophes whose threats could not be moderated, unless their effects are

addressed properly in advance. In fact, these concerns were the main subject of COP21 recently held in Paris.

It has been claimed through thorough research, involving the analysis of 11,944 scientific articles published between 1991 and 2011, that 97% of experts in the field find the evidence of human-induced climate change, (CC), highly probable (Leiserowitz et al. 2013). Nevertheless many politicians, corporations, and citizens at large, do not believe in it. For example, a survey conducted recently found that 63% of Americans had the conviction that global warming is happening but only 49% understood that its main cause was human activities (Cook et al. 2013). This is in line with Giddens (2009) findings when he says

> The politics of climate change has to cope with what I call 'Giddens's paradox'. It states that, since the dangers posed by global warming are not tangible, immediate or visible in the course of day-to-day life, however awesome they appear, many will sit on their hands and do nothing of a concrete nature about them. Yet waiting until they become visible and acute before being stirred to serious action will, by definition, be too late. (p. 2)

These statements go beyond climate change and encompass the concerns of the classical definition of sustainable development first outlined by the Brundtland Comission (United Nations 1987). Following this definition, the main objective of this paper is to appeal to all parties involved in making decisions related to climate change, sustainable economic, social and environmental policies, thinking that leaves future generations a blueprint for a sustainable resilient planet. The academia, private corporations, governments, and civil society are the main actors as decision-makers when the larger society is considered. Universities are part of this network, but all institutions have to be prepared to make internal changes to make themselves resilient and simultaneously seek the goal of a sustainable world. Research that was the basis for this article went beyond technological and climatological aspects, to encompass the decisions of a broader portion of society constituting these main stakeholders. Surveys, based on personal interviews and meetings with the aforementioned stakeholders, made possible the gathering of the data presented. The fundamental question this paper wishes to address is the following: *What is possible to change and/or, on what basis can decision-makers change the current and apparent status quo thinking on sustainability, characterized by postponements, delays and lack of mindfulness, as constructed on the information gathered in this analysis?*.

2 Methodological Aspects of the Investigation: Characteristics of the Two Different Samples About Renewable Energy (RE) and Climate Change (CC)

The studies mentioned used qualitative as well as quantitative methods. The latter also explored secondary data scattered in many official reports. Qualitative methods were used to build the questionnaires such as focus groups that its results were

added to the analysis later. Also, next sections summarize well-known reflections of higher education, public and private sectors institutions in Guatemala, that are familiar to all incumbents. Again, our main objective is to illustrate to decision-makers the needed internal and external changes that are urgent to make sustainable the development pursued in the near future. For this reason, we will use only those results that are strategic to prove the arguments advanced. In doing so, the objective is not so much to advance particular areas for further investigations, but to stimulate new research through monitoring and evaluation in a way, which could detect to what extent gaps observed in sustainability efforts are filled, dangers prevented and resiliency institutionalized in the weaknesses detected.

The quantitative studies targeted three specific populations, through a survey adjusted to each group and to each sample. Those groups were the following:

- **Top managers from private and public companies** in the area of RE and CC, mainly considering those corporations having a greater impact on citizens and the market. With regard to RE, hydroelectricity generation industries were selected from a list provided by the Guatemalan Ministry of Energy and Mines. In the case of CC, the sample was drawn from a non-exhaustive list of enterprises that covered the biggest corporations in agriculture and the industry provided by their respective chamber associations that represent them. After selecting these mainly private enterprises, managers answered questions through interviews and a structured questionnaire. In the case of the survey related to RE, we were able to have a list of enterprises, from the Ministry of Energy and Mines of Guatemala. Our interest in both samples was to gather data from the most relevant corporations having the greatest impact on the market. This fact is highly correlated with the size and production volume of each firm. For this reason, we relied on the selection of these cases in three judges that were characterized by their acquaintance with the activities of these corporations.

  They had to rank, in the case of RE corporations, all these enterprises by their relative importance giving a score from 1 to 3 points to them, being the latter the highest. As a result, corporations varied between 3 and 9 points for the RE list (the result of multiplying the number of points x the number of judges). The original one had 121 companies listed. Since the most relevant companies had our interest, we selected 51 cases with the highest scores and dismissed the rest. With regard to the CC sample, we did the same with some small differences. We ask our judges to rank between 1 and 5, therefore the highest score was 15 and the lowest 3. Once this was done, we selected 80 enterprises out of 1,376 listed, each one stratified by agriculture (40 cases) and industrial sector (another 40 cases). For all surveys, we had 80% or more of questionnaires completed.
- Teaching and administrative staff in careers and courses from Galileo University related to RE and CC. Galileo University was the only university selected in the RE survey because our interest for decision-makers was concentrated here. All cases were interviewed which is equivalent to a census. On the other hand for the CC sample, that was more a universal problem, we included the personnel that belonged to the main universities of Guatemala (seven were identified),

including UGAL and from an exhaustive list of 157 professors, 64 cases were randomly systematically selected and interviewed.

- **Decision-makers**: Managers, at the top of coordination offices or other units from different universities that have initiatives in the field of RE or environment, were included. The RE random sample covered four universities including UGAL. For the CC, we designed a stratified sample. There we could identify and add top managers belonging to government offices and NGOs that were in charge of specific activities in CC. For this category, we were able to identify seven universities, including UGAL. For the selection of NGOs, a similar methodology of judges that were used for corporations was applied.

Altogether, a total of 287 questionnaires of personnel from such populations and universes were gathered and completed. For the RE sample, 81 questionnaires and for CC, 206 cases were completed in the two surveys. In both instances, these interviews represented stratified samples belonging to each of the groups and subgroups described above. With regard to the RE sample, we were able to complete 51 interviews who were top managers of productive RE corporations. The questionnaires also considered teachers for their application. Most of them performed administrative duties (20). Finally, interviews were done to top decision-makers in four universities that were managing either research or teaching career programs (10). In the case of the CC sample, the following were surveyed: agricultural managers (32); industries (39); teachers (64), and finally different decision-makers from universities and public institutions (40) and NGOs (30) (Equipo Técnico y de Supervisión 2009, 2010, 2012a, b).

For the two RE and CC surveys, knowledgeable judges, based on official listings of companies and NGOs, selected, from a much broader list, those that they considered had the greatest impact on the market and on civil society. For teachers, exhaustive lists were identified, almost equivalent to a census in the case of UGAL, and with randomly selected cases for the main universities in the country. From these lists a random systemic sampling was made. As for decision-makers other than NGOs, respondents were randomly selected through comprehensive carefully prepared lists. The Statistical Package for Social Sciences (SPSS) was the program used for analyzing the data.

- **Limitations of the findings and suggestions made**. One has to be aware in advance that possible shortcomings of the analysis and the implications for decision-makers, may affect the issues selected and the measures advanced to fill those gaps that are suggested in next sections. Long-term periods are usually not a strong trait of politicians. Further research and changes in the academy largely depend on needed resources and donations which are markedly absent in developing countries. Civil society often looks irrelevant when their strongest groups have a monopoly of the influence to make effective lobbies that successfully prevail over the rest of citizens. Finally, the private sector may only aim to increase their earnings in a free market, relinquishing their social responsibility. Then, actual trends will tend to persist.

3 Results: Where the Changes Are Needed

Now, it is possible to make a summary of relevant results gathered to make decision-makers aware that sustainable present trends may not be sufficient, if detected weaknesses persist. From the research made, it was possible to distinguish five gaps that stakeholders from academia, the private sector, government and civil society (NGOs) need to close and ideally collaborate in its demise in order to effectively address present sustainability challenges, derived from social, economic, and environmental areas. Examples would be advanced particularly from the RE as well as the CC areas in Guatemala. It also could serve as a guidance that might be applicable to other countries with similar characteristics. The first two refer to sustainable universities and the other three put emphasis in the way that the knowledge and training those universities provide in this area may institutionalize in alliances and networks that could strengthen sustainability to all stakeholders in the academy, public, private, and civil society sectors.

4 First Gap: The Separation Between Research and Teaching

The presence of common features in the universities of Guatemala in the research was identified, such as few administrators handling many temporary professors in recently incorporated subjects like RE, CC, and the environment in general. The marked emphasis on teaching in these results makes evident the lack of research activities either as a generator or as a recipient of scientific databases among universities. This situation exists in many higher education institutions in Latin America. The research comes up as a great absent, compared to teaching which has almost the complete allocation of resources. Many observers, as well as professors themselves, put a sense of humor in this scenario. In Guatemala, names such as "Taxi Professors" have risen due to the constant traffic of teachers from one university to another. A somewhat irreverent, but sociologically relevant joke is told, which asks the question: "How does God compare to a temporary professor?" and the answer is that "both are everywhere, at the same time but nobody sees them."

The recent creation of careers related to RE also brings attention to the fact that few teachers have long periods of time being linked to the institution in which the career has been opened as it is observed in the quantitative surveys mentioned. The number of courses taught in this cycle versus the ones taught in the past one is relevant for extending this analysis. Regarding professional performance, an obvious preference from teachers toward training and education emerges. This is particularly relevant when compared to other areas of the value chain. The teaching staff aims to this new area (RE), due mainly to previous academic background, but also guided by a previous relationship to that productive sector of the labor force or motivated by their interest in these innovations. Among the sectors, where the staff said they worked before, the hydraulic sector is presented in a relevant manner,

which is highly correlated with the potential for electricity generation of Guatemala in this field (Equipo Técnico y de Supervisión 2009, pp. 1–20). Hardly less than 10% of their potential is actually used.

Power generation, as main occupation, in comparison with distribution, commercialization, transport, and other activities, has also greater preference among the teaching staff. Consistent with the above, the interest in receiving training is centered on hydraulic and biomass energy, even though wind, solar, and geothermic energy receive special attention as well but with less emphasis. Related to this, the need to access a scientific database also arose. However, to lesser extent, significant percentages favoring a greater operational link to the RE industry and the need of updated capacities in this field were expressed (Equipo Técnico y de Supervisión 2009, p. 61).

The inquiry made to teachers at the Galileo University also covered research activities, funded by the RE market, including industries as well as governmental and international cooperation agencies. In general, these efforts were very moderate according to the data collected. In addition, the need to forge a greater link between students and professors to the practice of the industry through more exchanges, internships, or supervised practices, contributed to this gap. Moreover, a greater preference on the part of respondents, regarding the requirements of training per sector was observed. The upper strata of professors, measured through seniority were inclined to receive training of different kinds of energy such as hydraulic, geothermic, and solar, while the middle and lower strata tended to prefer biomass (Equipo Técnico y de Supervisión 2009, p. 29). Similar results were obtained in the survey on climate change (Equipo Técnico y de Supervisión 2012a, p. 82). Nevertheless, the common characteristic among all incumbents was precisely the wider gap between research and teaching activities.

5 Second Gap: Lack of Links and Synergies Between Specialized Disciplines and the Multidisciplinary Nature of Environmental Studies

In light of this gap, a strong need arises for curricular reform, which will evaluate and suggest content for courses, in a transversal manner as the effects of RE, environment, and CC are related to different careers like architecture, law, information technologies, communication, engineering, human sciences, and others, particularly those energy-related careers. The survey specifically asked decision-makers, about the CC knowledge that the people dependent on their programs had. It was significant that among the courses related to RE, while the topic of environment was often mentioned, the issues of climate change were not (Equipo Técnico y de Supervisión 2009, p. 73). This can also be applied to the results of climate change. In this sample of teachers, the majority of university decision-makers mentioned that among the professors that taught environmental

studies in their related careers, their "understanding of climate change was vague" (regarding CC) (Equipo Técnico y de Supervisión 2012a, p. 90).

On the other hand, practice dictates that the groups that work in RE often have a weak connection with those implementing the environmental subject and, as previously mentioned, the issue of CC often becomes something marginal and distant. Furthermore, the stakeholders involved in environment courses have not fully realized what CC means, showing a vague awareness of the subject. This divergence is also noticed in the lack of coordination that exists between the Guatemalan Ministry of Energy and Mines and the Ministry of Environment and Natural Resources. In terms of CC, this tension largely influences the separation of mitigation and adaptation policies. In the case of Costa Rica, a neighbor of Guatemala in the Central American area for example, these public policies belong to one single Ministry that calls itself "Energy and Environment."

6 Third Gap: Lack of Synergies Among the Various Sectors to Which the Different Stakeholders, Who Tend to Segment Their Activities, Belong

From the year 2007–2008 on, a greater openness to public–private collaboration and multidisciplinary activities is noted. Nevertheless, it is also perceived that it is still necessary to expand the connection among the first mentioned sectors as well as their link among their institutions, RE, environment, and CC. Practices related to new teaching schemes in the RE field have occurred mainly since 2008. This coincides with the oil crisis, whose prices in global markets were then over US $147, which is a historical amount for that year. It is common among university units in Guatemala that such practices lack a research component that feeds and updates teaching. However, our informants in the research, mentioned greater openness to public–private collaboration and interdisciplinary programs or toward the use of the "know-how" of experienced staff on subjects different to RE, CC, and environment. Nevertheless, there still is a considerable margin on which to deepen this needed tendency in multidisciplinary teaching and practices. For example, according to our interviewees, barely half of the organizations surveyed focus their activities using a strategic plan. In addition, only half of the previous figure (hardly 25%) met their own adopted goals to a high degree, according to their approved strategic plan (Equipo Técnico y de Supervisión 2009, p. 73).

The irreconcilable dichotomy between specialization and multidisciplinary approaches tends to disappear when short-, medium-, and long-term goals are considered seriously. In the short term, technical careers and specializations make an immediate impact on the demand for the offered product in the market. However, in the medium- and long-term, an expansion toward other disciplines would be necessary because of the growing importance of sustainability issues, RE, and CC as national priorities. Then, other problems and related disciplines emerge such as public policies on information technology, new management innovations, social

work around conflict resolutions, and interdisciplinary relationships in both the public as well as the private sector. This aspect has to guide decision-making toward plans and strategic objectives that have specific time deadlines. When this is not accomplished, there is an internal detected weakness externally derived from the lack of inputs coming from alliances among the academy, private, governmental, or civil society sectors. How is it possible to reach these last networks? Next section will attempt to answer this question.

7 Fourth Gap: The Existence of Large Deficits in Coordination Efforts

There is a lack of investment and coordination efforts compared to what is needed. The efforts must match required level of risks found in sustainability, RE, and CC activities. For example, convincing measures have to be adopted that could build an alternative to environmental degradation and GHE effects. This ideal situation fulfills the need for greater internal and external coordination with other agencies and institutions with the same common objectives which is the aim of Fig. 1 for the case of Guatemala.

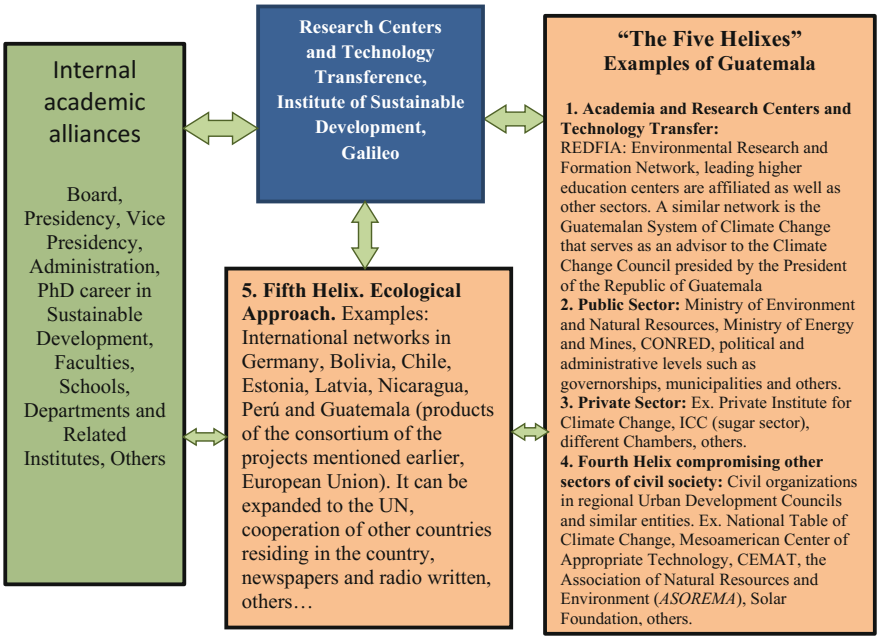

Fig. 1 Partnerships in building a system of action based on the Five Helix approach with examples pertaining to Guatemala *Source* Own design: Galileo University Technical and Supervision Team

This space provides the scenario for using the so-called "Quadruple and Quintuple Helix" approaches, seeking common goals among the academia, the private sector, the government, and civil society. These four sectors constitute the pallets of the helix. The ecological approach constitutes the fifth. The creation of networks that address mutual defined concerns evolve in the light of this concern. The outlined approach has emerged from a teaching–learning process regarding the ideal nexus to the actors that are more capable of making a difference in the evolution of sustainability, RE, and CC. Figure 1 shows this reflection for the case of Guatemala. The right side shows the four pallets of the helix while the one in the middle is an amplified effort beyond a specific country but using the ecological affiliation as the axis for collective efforts. Finally, the column at the left attempts to highlight the importance of internal coordination efforts in the same direction. The last ingredient is provided by the Institute of Sustainable Development within the Galileo University that is at the center of all efforts.

A historical account of these thoughts is warranted here. First, the "Triple Helix" approach was adopted (González de la Fe 2009) in the 60s. This strategy arose from concerns of the US government regarding an intercontinental ballistic missile attack, during the tense moments of the "Cold War." The question to be answered was the following: "How could the US government decision-makers communicate in the face of such an unexpected attack if it occurs?" From this, the Defense Advanced Research Project Agency (DARPA) in charge of maintaining technological supremacy in this field came to the rescue. At this point, only the military and the government were present. They were the seed of further changes that covered the whole society later on.

These activities began to involve the private sector and academia, especially those most interested in a broader society such as entrepreneurial, agricultural, and technological universities. In the end, scholars agreed (González de la Fe 2009) that it was from these sources of innovation that the current Internet and related social networks and corporations emerged. Today, they occupy the first places in this field and are the advances of a new "Knowledge Society." Reflecting on the model, this first coordination effort was called the "Triple Helix," attributing their excellence to the joint collaboration and alliances of the government, private sector, and academia. This approach currently counts with regular meetings and numerous publications. Later, the need is identified to include a fourth and fifth pallet and their scope is amplified to a "Quadruple and Quintuple Helix," therefore encompassing civil society (Helix Research 2013) characteristic of the Quadruple and the ecological approach of the Quintuple elaborations (Carayannis et al. 2012). The team involved in research at the Universidad Galileo considered these last approaches to be more appropriate for developing countries. The concept is graphically described in Fig. 1.

Although Fig. 1 applies to Guatemala, similar elaborations might be extended to other countries. It is possible to generalize that in addition to the often low cooperation among these different pallets and these separate entities by themselves, including the government, coordination and investment in this area is lacking. It can be observed that the RE sector, despite being one of the solutions as an alternative

energy to GHE effects, usually, when examining pensums of different related careers, the relationship is distant or nonexisting at a research, teaching, or technology transfer level. Of the information collected, the lack of internal coordination may also be noted, even within the institutions themselves and within the academic sector in the area of RE as well as CC (Amaro et al. 2014a, b) and between RE and CC.

There are "perverse" organizational trends that emphasize "sectionalism" and building of "fiefdoms." Universities have tendencies of seclusion within their walls, to create "ivory towers," without continuous contact with the rest of society. After all, it was universities that invented the concept of "cloister" to refer to the teachers of a particular faculty which is a concept inherited from medieval times. On the other hand, the government is more open to vertical relationships, often considering itself as the leader of certain areas and having difficulties with horizontal relationships, specifically when they relate to citizen organizations and networks, belonging to civil society. Furthermore, the private sector tends to be oriented exclusively to maximize their rent, neglecting at times their "corporate social responsibility." Finally, the civil society involved in many organizations with different objectives tends to a dispersion that poses the risk of spreading the investment of resources to many areas, forgetting broader priorities. These trends tend to perpetuate actual trends and paralyze any sound intervention in sustainability issues.

8 Fifth Gap: Lack of Linkages Between the Short-, Medium-, and Long-Term that Tends to Postpone Action Indefinitely

This gap prevents gaining awareness on sustainability issues. It contributes to urgent decisions delays and jeopardizes the prevention and proper handling of matters according to specific time periods. It is not only disasters and threats like storms and flooding. It also refers to other factors that may become lasting solutions that need to be addressed today looking for an impact in the long term. Mitigation of GHE, looking for lower temperatures at the end of the century is a case in point. It is then necessary to link the short, with the mid- and long term as inferred, for example, from the storms that have desolated Guatemala in 1998 (Mitch), 2005 (Stan), 2010 (Agatha), and 2011 (E-12). These storms have represented between the 0.63 and 3.4% of the GDP (Amaro et al. 2014a, b). This gap leads us to conceive temporal dimensions in the light of elaborations made regarding the "smart management" of extreme climatic events (Mitchel and Ibrahim 2010). The following temporary dimensions as illustrated in Fig. 2, follows this approach:

Ex-ante event: Preventive measures are called at this point in time, based on the use of early warning systems, announcing the population about the evolution of the event and if needed, the provision of training on these preventive measures they should adopt. Warning systems register the degree of risk in stages. For each degree

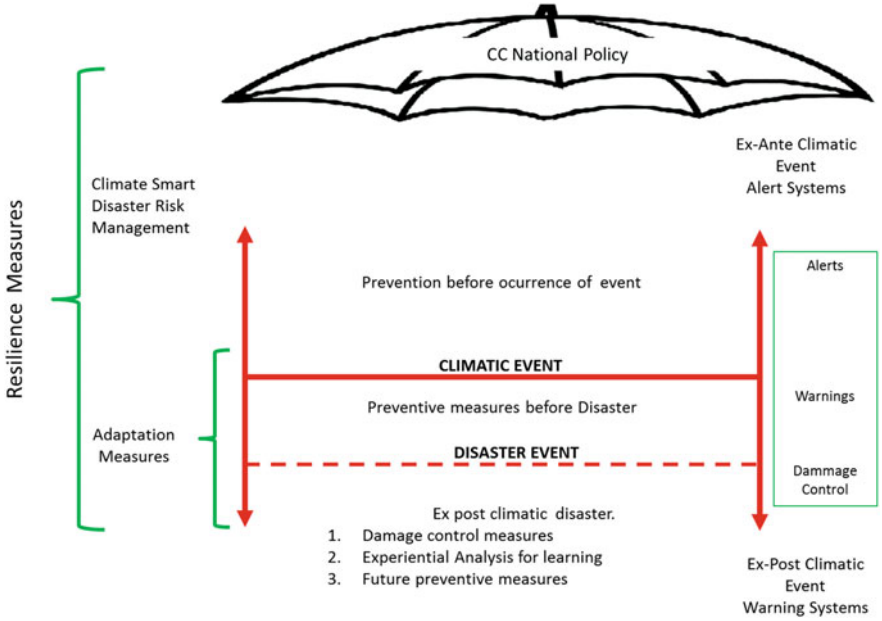

Fig. 2 Approach of a management system for adaptation in relation to the identified risks and disasters. *Source* Own design of the Technical and Supervision Team of the CELA Project

of risk, protection measures for neighbors are developed, including the properties of the people involved.

During the event: When the event occurs the degree of alert changes in order to provide warnings to the population about the impending disasters. In a similar manner to the alert system, these warnings induce the reactions of the community to minimize impact. A communication system keeps the community informed, including neighbors located in the most remote areas.

Ex-post event: After the event, damage control measures develop from which knowledge is obtained for developing preventive measures for the future when similar events break. The suggested resilience system seeks to integrate all the experiences to face the risks of environmental improvements, disaster, reinforce adaptation capacities, focusing on the causes of poverty, population, and territorial vulnerability. This approach is called "Smart Climate Risk Management." Figure 2 makes important distinctions that could be incorporated to a strategic plan (Mitchell and Ibrahim 2010). The graphic highlights components of the strategy to be followed, according to different time periods that start before, during and after the occurrence of events related to environmental threats and extreme climate changes as illustrated in the same figure. This approach should be framed taking into account the following limitations and characteristics:

(a) While there are common findings arising from the different samples, the degree of sensitivity to the threat of climate change differs by territorial areas. Agricultural companies gave to this issue greater importance than in industrial ones in the Guatemalan surveys reported. Meanwhile, teachers regard the issue as a vague dimension of the environmental theme and decision-makers still do not clearly prioritize immediate and mid-term threats to their activities from these unexpected changes. In general, it could be said that in all the populations considered for the surveys: companies, teachers, and decision-makers, there is just an opening to incorporating the subject of climate change to the processes of research, creation of plans, policies, programs, laws and regulations, investment, execution, follow-up, evaluation, and feedback. "Quadruple and Quintuple Helix" activities should be directed precisely to achieving a network system capable of coping with the threats that climate change may bring (Helix Research for the CLIQ project co-financed by European Regional Development Fund and made possible by the INTERREG IVC 2013).

Industrial enterprises are somewhat behind because they have had to face to a lesser extent these threats and realities. Nevertheless, the agricultural companies, in the case of Guatemala, exceed the world average in terms of the degree of importance attached to this variable, while the industrial companies are below the world average (Equipo Técnico y de Supervisión 2012a pp. 48 y 49; Enkvist and Vanthournout 2007). However, the lower the educational level of the staff employed in agriculture, with the exception of senior managers, is a limitation to the introduction of innovations that require a higher expertise. This is observed in the fact that at least some industries have begun to measure their carbon footprint, while the same practice is not present in agriculture. In addition, a growing trend in most industries is to affiliate themselves with organizations that promote corporate social responsibility, although there is still a long way to go for this innovation.

(b) Priorities differ according to the nature of the entities: naturally companies focus more on production, teachers on research and teaching, and decision-makers are concerned with national problems. However in all these cases there are considerable deficits. There are still major specific concerns from businesses in general, as is natural, regarding the chain of production. For example, the fragile road infrastructure that may threaten or interrupt the supply chain, or the problems derived from the pressure of stakeholders regarding the environment that could have an impact in an increase in the costs of production or public prohibitions. Here, reservations came up by managers' firms regarding prohibitions and limitations to the exploitation of natural resources. On the other hand, these concerns are not present to this extent, among teachers and decision-makers from universities, government, and NGOs.

The main actors interviewed pointed out the differential impact to be expected in the future. Agricultural enterprises were very specific in the changes they deemed necessary in order to develop new technologies and methods of plague and disease control. For example, they mentioned programs of planting and harvesting, the design of new crop calendars, and techniques that will allow planting and reaping in unusual dates, the transfer of crops to new altitudes and the introduction of new irrigation systems with more efficient water use. For their part, the industrial managers expressed their concern regarding disruptions on the supply and distribution side. Also they mention the impact of infrastructure damages, but confirmed that their activities were more resistant and can better adapt to climate problems, reporting that there are few cases of frequent and permanent damages in all operational processes at a disaster scale.

There would be room, however, to face the future over CC threats, by industrial companies. For example, they may develop capabilities in green building technologies, clean development mechanisms, including carbon market tendencies, emission reduction technology, risk management, and improvements in energy efficiency. There might be a particular concern also about water management, which is common among both industrial and agricultural companies. Agricultural companies tend to focus more on irrigation problems, while both agricultural and industrial companies are concerned with efficient and productive use of water and preservation of springs. On the other hand, professors are more inclined toward teaching and research as well as to interdisciplinary programs to investigate the effects of vulnerabilities and disasters in the country. It is particularly striking to observe the low priority on needed legal proposals and regulations. On the other hand, decision-makers in the public and non-governmental sector, have more concerns of national character without territorial references when they compare with companies and teachers. Nevertheless, they express their concern for the coordination of their hierarchical structures before any climate threat throughout all the country.

In general, the interaction between the three sample populations had particular traits. Universities have generally concentrated activities within their own campus. In turn, they show less ties (or "bridges" or networks) to other private corporations, civil society, and government. While this aspect may aid the intellectual production per se, their intensity could lead the academy (as a whole) to give their back to national problems and criticisms from the rest of the stakeholders of society that regard universities as "ivory towers." However, in viewing the environment, greater coincidences emerge between decision-makers belonging to the public sector and non-governmental organization, as should be expected. Both entities address citizen issues, and it is from this common characteristic that the frequent association arises between state activities that finance programs that NGOs implement. In spite of this, these alliances could have a lack of transparency derived from the private or non-governmental nature of entities that despite having a citizen orientation possess in great measure a private nature.

(c) Research and technology centers of the academia should have priorities regarding possible adaptation measures that could have the support of agricultural and industrial sectors for "green" solutions, clean development mechanism, mitigation, and energy efficiency. Table 1 summarizes an example of the suggestions given by different stakeholders of the industrial and agricultural sectors, regarding the main needs they have that universities may help. These suggestions are general and specific. Table 1 uses water as an example because it is increasingly becoming a strategic resource. This example is applicable to other strategic areas as well. Necessity suggests making a common practice of the knowledge gained, scaling it up or down according to the challenge presented.

(d) Along these lines, respondents in the survey suggested other activities that may strengthen the alliance of the sector with university activities such as definitions of common research objectives, partners' agreements, networks, internships, supervised professional practices, technical assistance given by specialized university personnel to other sectors and the mutual development of patents. The priorities for these technology centers should then revolve around the knowledge elements highlighted in the following Table 1, using the example of water as a strategic resource.

Table 1 show possible courses with specific concerns of managers related to hydroelectric, agricultural, and industrial plants. The idea of outlining these priorities is the appeal that they represent for decision-makers in relevant careers at the

Table 1 General and specific suggestions regarding knowledge and general management and that of water as an example for other specialized areas

Priority	Industrial	Agricultural
General		
1	Technology for green buildings	Methods and technologies for plague and disease control
2	Clean development mechanisms (CDM), carbon markets	Technology to modify the dates of planting and harvesting
3	Technologies for emissions reduction	Adaptation and introduction of new crops and varieties because of climate changes
4	Risk management	Technology for crop adaptation to different heights
5	Technology for better energy efficiency	Technology and methodology for earth handling
Water management		
1	Technology for water reuse	Irrigation technology
2	Technology for efficient water use	Technology for efficient water use
3	Technology for spring preservation	Technology for spring preservation

universities for designing areas of knowledge and training for these specific groups. Water is just an example. This exercise repeated in other areas may cover public policies, social organizations, administration, human resources, climate sciences, risk analysis, financing, etc. What we should have in mind is that sustainability implies many sectors and disciplines that look at specific transversal issues.

What is required to expand this scope is to engage in a curriculum reform that connects universities with the larger society. Other plans, policies, programs, and projects are possible to devise. In this sense, the term "bridges" is probably more appropriate. These possible "bridges" are the following.

Mutual research ventures that capable of forging alliances among business, academic, public, and non-governmental sectors.

- Multiple agreements and collaboration projects, to be detailed and agreed upon.
- Multiple strategic alliances based on objectives that may build true networks in a given field of interest.
- The creation of internships that could help students gain and accumulate professional experience, by placing university students in other sectors. This way they contribute to these host entities and the system as a whole.
- The encouragement of a Supervised Professional Practice (EPS by its name in Spanish), where Guatemala has extensive experience, created by all interested entities that demand and practice external activities related to the curriculum of the universities. They are assigned to functional sectors as well as territorial entities searching for a decentralized approach.
- The provision of technical services of the universities toward companies, public sector, between universities themselves and non-governmental organizations, while helping these entities to develop more openness to strengthen the alliance and common goals through lectures, forums, graduation thesis contributions, etc.
- The combined development of patents that are derived from the research work carried out by the concerted participating entities.

(e) Specifically, it becomes necessary based on the priorities claimed by those surveyed, to work on research and technical applications to the following adaptation measures with significant curricular reforms. This reasoning would lead to an expansion of Table 1. Respondents suggest including the issue of environment and climate change in the following careers:

i. Engineering and Architecture: Through risk analysis, contingency plans, clean technology, recycling and efficient water and energy use, and the design of "green buildings."
ii. Agriculture: Development of crops and varieties with greater resistance to drought, diseases, and adaptation to these new climatological conditions; reforestation and protection of water resources, new techniques for soil management, irrigation technology.

iii. Economic Science and Business Administration: Risk analysis, contingency plans, clean technology, recycling. Incorporation of environmental variables to national and private accounts.
iv. Information and Communication Technologies: Redundant systems for protection of data, redundant communication systems, and early warning systems.
v. Human Sciences: Social dimensions of early warning systems, organization and planning of risks, public participation techniques in the aforementioned areas, public policy advocacy and conflict resolution.

Finally, managers consider that training on issues related to climate change should be conducted within the company, at work and through distance learning. On the other hand, universities should develop innovative training systems, incorporating those modalities. All the suggestions made will consolidate multiple alliances and activities that will make the universities in Guatemala more sustainable. Many of these innovations may be applied elsewhere in developed as well as developing countries. Consolidated networks will help to face the challenges implied in the sustainable development of all the planets in the future as has been proclaimed by the last 2015 General Assembly in New York and COP21 in Paris.

9 Conclusions and Recommendations for Decision-Making Regarding Renewable Energy and Climate Change

If the suggestions made in this paper become a reality, a vision of the future may emerge in its conclusions. The lessons suggested in this paper would strengthen the sustainability of the university, making her more responsive to corporations that in the process will acquire greater consciousness of their social responsibility. Simultaneously, governments will be more open to horizontal relationships when they realize the benefits of greater formation and share responsibilities with experts in their main fields. Civil Society will increase their participation in public issues, contributing to their organizations to the well-being of all citizens and focusing better their efforts thanks to the new knowledge and training they will receive. Universities will offer professionals in different careers as always, but they will have a common approach exercising their expertise when they will make compatible development (including their socioeconomic components) and environment and a renovated concern with future generations.

Obtained results in these surveys indicate the need to make significant changes in the ways training and formation constitute usual practices at the universities. The challenges that arise under the umbrella of sustainable development request a renovated staff at the decision-maker level at the universities, private sector, government, and civil society organizations.

From the analysis, a first gap arises suggesting that decision-makers in the academia, private sector, government, and civil society must address. It refers to the breach between research and teaching at the universities and its repercussions in the larger society. The lack of investment resources for research, the absence of laboratories in which to carry out these activities, the low offer of specialized personnel that meets the expectations of every university, are limitations to face this challenge. Ideal demands prescribe that teachers write, investigate, and teach. However, difficulties in the access to knowledge and other research institutes, deficiencies in procuring adequate training, lack of specialized publications that acknowledge even the smallest efforts determine little or inexistent generation of patents. In addition, the lack of private, civil society, and public sector interest in providing this platform, among other factors, deepens this gap.

The second gap identified is that which arises from sustainable development issues in general, renewable energy and climate change. Knowledge segmentation is also a distinguishable pattern here. This practice is almost a corollary of the first gap. An absence of linkages and synergies in the curriculum of careers most related to environmental impacts, tend to separate their knowledge from other areas. On the other hand, the groups that work in renewable energy in the labor structure often have little connection with those implementing environmental issues. Particularly, climate change becomes something marginal and distant from the larger society and vice versa.

A third gap that contributes to the latter, relates to specialization as opposed to a multidisciplinary perspective. In the latter, there is reference to the difficulties of inserting other different disciplines than those focused on the detection, design, and exploitation of environmental issues, energy sources, and climate change. When one puts the emphasis in temporary and strategic periods designed to overcoming this gap, the possible tension may dilute, if the teaching–learning process is oriented to specialized knowledge in the short term but giving room to multidisciplinary views in the long-term.

The fourth gap that was mentioned, can also be extended to both RE and CC from a sustainable development perspective. It refers to the deficits in the internal and external coordination within each decision-makers group, including universities and the interaction among the different sectors themselves: academic, governmental, entrepreneurial, and non-governmental groups. This absence prevents synergies that could move both the objectives of the priorities of renewable energy in the country as well as those of climate change and sustainable development in the short, medium and long term. Hence, needed decisions around this gap suggest an innovative approach adopting the "Quadruple and Quintuple Helix," which encompasses an ecological focus together with a close collaboration among different sectors through joint networks involving the academia, private sector, government, and civil society groups.

The fifth gap refers to the lack of perception and therefore connection between the temporal dimensions of short, medium and long term that may link the issue of climate change with the factors that affect it. It is not only about disasters and threats such as storms and flooding but also plans, policies, programs, and projects

that should suggest solutions like the subject of renewable energy as a remedy for this situation. A key aspect to consider is the objective of how to tackle climate change. Its threat is so pervasive that by itself may order and prioritize the entire sustainable development area with its many repercussions, disciplines, and subjects in areas that are normally distant from each other and that contribute to the dispersion of goals and dilapidation of resources. Supporting the existence of the previous five gaps and seeking their convergence is necessary to suggest the application of preventive "smart" strategies in the face of threats and risks of climate change, before, during, and after the event. This appraisal should introduce the short and medium term in addition to the long term, to be effective in coping with this phenomenon. These decisions would force all actors to behave accordingly, dismissing the attitude that influences doing nothing because it is a threat that belongs to the next century.

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Note: The publications related to the JELARE and CELA projects listed in the first page of this publication, may be found at www.galileo.edu which is the central online page of this university. The publications are in the section titled "Investigaciones" which is at the left of the mentioned first page.

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