AC 2007-1641: A COMPARISON OF FLOOD MANAGEMENT PRACTICES BETWEEN GERMANY AND THE USA: AN UNDERGRADUATE RESEARCH PROJECT ON SUSTAINABLE PRACTICES

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A Comparison of Flood Management Practices between Germany and the USA: An Undergraduate Research Project on Sustainable Practices

Abstract

The Purdue School of Engineering and Technology at Indiana University–Purdue University Indianapolis (IUPUI) offers a three credit hour study abroad course which focuses on sustainable development, globalization, and German culture. Undergraduate students have an option to add another three credit hour sustainable research project to their studies while in Germany. Students can select a sustainable project and work with one of a number of different German industries, municipalities, or universities or they can elect to conduct an individually designed sustainable project on their own. This paper will feature highlights from one student's project, who worked with faculty and researchers at the University of Applied Sciences Magdeburg-Stendal (FH), Germany and the Institute for Water Management and Ecotechnology for four weeks during the summer of 2006. The student's research project focused on the flooding practices of Germany and the European Union and comparisons with those in the United States.

This paper will also provide information about how this undergraduate research program works for students, faculty, and mentors. Issues for practices and future research will be addressed.

Introduction

Today, one sixth of the world's inhabitants are estimated to live in the potential path of a 100-year flood and, unless preventative efforts are implemented on a world wide basis, that number could double or more in two generations [1]. In addition, approximately 140 people are killed annually and six billion dollars in property damage is caused by flooding events each year in the United States [2]. In Europe, flooding is the most common type of natural disaster. Floods can kill people, make them ill, leave them homeless, damage property, and/or pollute the environment, which is why taking a holistic view of flood awareness, prevention, and management is so important in today's world.

Flooding is a natural part of the hydrological cycle but has become an all too frequent risk due to climate changes[3], especially given improper construction and management of water plains with enlarged population located in flood risk zones. The United States and Germany are both marked with abundant rivers that are often prone to flooding.

European National and Transnational Water Management System

There are three major rivers in Europe that thread through many different countries. The need for cooperation for river management between countries is taken seriously in those countries. Problem with water quality, modified water bodies, insufficient river continuity, deficits in migration of species, floods and droughts are just some of the issues that are addressed. The European Union developed a Water Framework Directive where all countries had to report on the status of their rivers by the end of 2004. The report showed that many rivers and stream had been straightened or modified, many were still polluted, banks were changed from their natural form and almost all flood plains had been cut off by dikes.

The Water Framework Directive has turned out to be the most important legal tool for transnational cooperation in Europe and has brought about many improvements of river basin management because of its existence. [4]

Regional Water Management System

A regional system of flood management is needed to prevent, respond and control the devastating effects that are the result of a major flooding event. This requires the networking of three aspects of the water management to join together and work as one system. The first is a technologically based, holistic approach to flood management such as the use of a Geographical Information System (GIS), which enables users to explain where the flood zones are and prepare flood hazard maps for the vulnerable areas. The second is the implementation of non structural, sustainable, techniques to naturally avoid devastating damage and loss of life, such as correct zoning for buildings in flood plains, wetland conservation and reclamation programs. Finally, the third component is the increased level of community awareness and involvement in these flood prevention techniques. Effectively combining these aspects of flood management can result in a sustainable, effective, and efficient system. Regional Water Management Systems are used quite regularly throughout Germany and Europe.

Comparisons in Germany and United States

There are significant differences between the population to land ratio, amount and size of rivers and the management of floodplain systems in Germany compared to the United States. However, in the past 30 years there has been a similar amount of significant flood devastation in both countries. Germany has approximately one third the population of the United States and is physically comparative to the size of the state of Montana. There are six main rivers in Germany that have a history of noteworthy flooding. They are, in order of largest to smallest in length; the Danube, Rhine, Elbe, Oder, Weser, and Ems. Germany shares these rivers with their surrounding border countries. The United States on the other hand, has approximately 24 main rivers approximately four times the number of rivers in Germany, which are also dramatically larger in terms of length. More crucial than length and size of the actual river is the extent of the river basin in terms of flood management. A river basin is technically referred to as a drainage basin and also known as a watershed in the United States. It is the area of land that water from rain or snow will drain downhill and into a body of water such as a river. So the drainage basin would be the streams and channels that would flow into the particular body of water and the area of land over which the water drains.

The Danube, Germany's largest river is 1,794 miles (2,888 km) in length, and its drainage basin is 315,443 square miles (817,000 km²) in size. For comparison purposes, the Mississippi River, the largest in the United States is 3,900 miles (6,270 km) in length and its drainage basin is 1,151,000 square miles (2,980,000 km²) in area. This is a dramatic difference in river length and drainage basin size for the largest of watersheds in Germany and the United States, but yet the damage caused by river flooding in both rivers is quite similar.

There is one more important term to define to properly discuss flood management and that is a floodplain. The drainage basin is the entire area in which the water can drain down into the river. The floodplain is the low level land directly around the river that is prone to flooding during an event such as flash flood, dam or levee failure flood, ice jam flood, etc. The focus

of a flood management system is directly on the flood plain and the use of structures such as levees and dikes are among the most common means of preventing the flood plain of flooding and causing destruction and sometimes even death. A levee is built parallel to a river at a downward sloping drain into the river. It is good at preventing the water from flooding the direct floodplain area, but levees tend to speed waters further downstream which is dangerous and can actually make the flooding and damage downstream much more severe. The United States has always invested in this type of flood prevention and the Mississippi River levee system is the biggest system in the world. See picture 1, as a visual for what a typical levee looks like on the Mississippi River.

Picture 1: Mississippi River levee at Gretna, Louisiana

The levee is not a perfect solution to flooding and has the possibility to fail in a many ways. One of the most common ways a levee can fail is called a breach. A levee breach is when part of the levee actually breaks away, either suddenly or gradually and water quickly flows into the opening and floods the area behind the levee. The usual cause of a levee breach is surface erosion or a subsurface break. A levee also fails if the waters simply "overtop" the peak of the levee. This can also occur from high winds that generate swells in the river and bring big waves of water over the levee.

As far as flood history in Germany compared to the United States there are some tragic similarities. Germany has records of significant flooding for the past 800 years, whereas, the United States has information of flooding catastrophes from only the past 200 years for comparisons. In the interest in pursuing current research, flooding from the past 25 years will be used as examples to evaluate current system successes and failures. A comparison of flood management between the United States and Germany is needed to further examine similarities and differences that are in use or that may have relevance for the other country to observe and possibly implement.

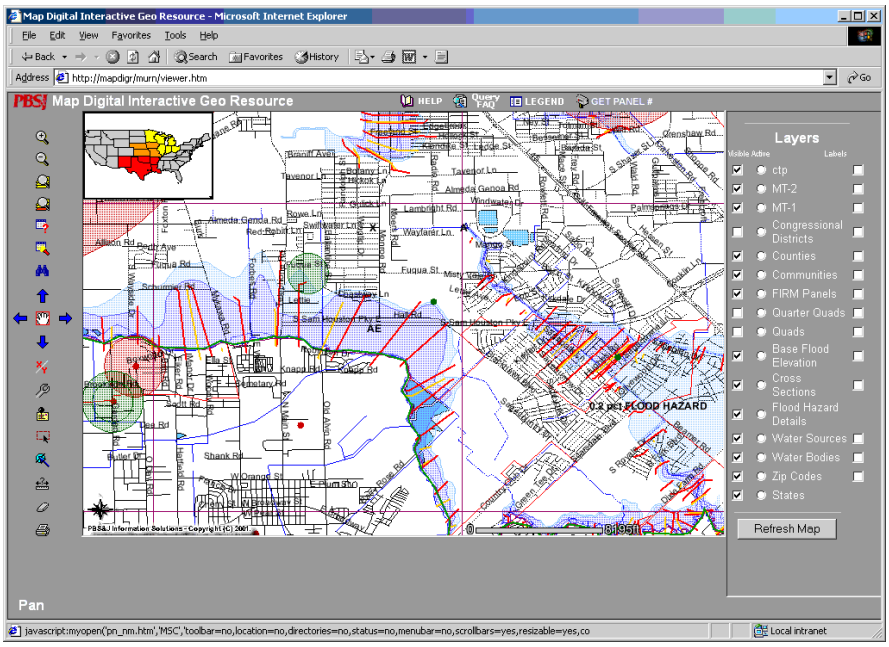
One of the biggest and most damaging floods in Germany was in 2002; it affected mostly the state of Saxony-Anhalt in terms of damage. This particular flood event in Germany caused the death of 38 people, as well as an estimated 11.3 billion Euros of property damage. If there is any good to come from a flood it is the increased sympathy of citizens to do everything to support the public officials to lessen the severity of future flooding events. In Germany, the 2002 flood sparked the development of an integrated flood management system for the Stendal County in Saxony-Anhalt. The flooding of the U.S. Midwest in 1993, specifically in the State of Mississippi was directly linked to 38 deaths in addition to 12 to 20 billion dollars in damages. This was seen as one of the most significant flood disasters in the

United States and convinced politicians and city planners to be more considerate of city zoning with respect to floodplains.

Technology and Flood Management

Since the birth of computers there have been opportunities to translate data and information from a physical media to a digital media. Such technology includes the use of a Geographical Information System (GIS). This is very important to flood management because it enables responders and decision makers to have the most current information, as well as be able to manipulate the data to work out various scenarios. In combination, with this a Digital Elevation Model (DEM) is the most useful means to approximate flood depth. The DEM's accuracy depends on the quality of information from remotely sensed or hydrological data which can be shared by government entities. The use of these modern instruments to generate the most current hazard maps can greatly assist authorities to make a proper response and greatly increase the overall efficiency in flood management.

The Federal Emergency Management Agency (FEMA) of the United States has only a fraction of the river data translated into a digital GIS. They primarily contract out the duties of managing and updating the most recent possible flood map information for some of the most frequently flooded areas of the United States. See picture 2 as an example of what FEMA may use as a reference before, during, and after a flooding event.



Picture 2: Example of a web-enabled application for FEMA response workers to use.

In Germany, there is much less land to cover but it is important to note that on average the density of people living in a flood plain is greater than the United States, therefore, much of the new technology approaches to flood mapping have been accepted and put to use. However, the United States relies on FEMA to gather its information, while Germany has a regional and cross border collaborative approach to gather the most current data for flood hazard mapping and therefore has completed their system.

Sustainable Techniques

There is no way to prevent flooding catastrophes, but there are ways to reduce the loss of life and property through effective methods of prevention with the focus of sustainability during city planning or re-development in a floodplain. Sustainability is development that maintains or enhances economic opportunity while respecting, protection and restoring the natural environment, which people and economies depend. Sustainable re-development is simply the application of the concepts and practices of sustainable development to the disaster recovery process after a flood. Sustainable re-development techniques can also be applied to other disasters such as fires or tornados. In the United States, flooding has been primarily controlled by structural measures such as levees, dams or retention ponds. There is much energy and resources that go into this type of structural measures of flood prevention, but is it really the most effective answer? One could argue that if a dike or levee would fail the resulting flooding would be worse than if there was no dike or levee in the first place. This is not to say that a levee is a bad means of flood prevention, it means that perhaps there should have been zero development in the flood plain to start. If there is no population or property in the flood plain then there is no problem in the case of a big flooding event. The flood plain would be able to retain and absorb the waters faster and would also eliminate a large amount of the pollution associated with flooding in populated zones. This is not a completely effective answer because people have and always will have a desire to live near water and there has already been large development in flood plains throughout Germany and the United States. It is good, however, to look at alternative areas to develop outside of a flood plain or go the extra steps to insure safety and awareness for inhabitants that choose to live in a flood plain without compromising the natural ecological state of the area.

Sustainable Examples from Germany

Flooding is a result of an over abundance of water that has no where to readily drain. There are many simple strategies that a community could achieve that would be economical and sustainable. There is an exceeding amount of concrete and pavement that are common in cities and this acts as a catalyst to flooding because the waters simply run over the pavement and pools in the floodplain like water in a bowl, where as water in a sieve would simply drain down. Germany has implemented this obvious solution in many of its cities such as Mannheim, Freiburg, and Potsdam. Instead of paved areas that allows no means of drainage, (See picture 3) the parking area has a grid-brick pattern allowing water to drain into the ground. There are also measures for water to drain into the sewer if there is too much water to be drained naturally. In addition, note the grid pattern again on the side walk next to the parking areas. This is so easy to do and also aesthetically looks so much better than just solid concrete blocks that are commonly used in the United States. There are many types and examples of porous pavements and they are quite commonly used in Europe, especially in Germany. This type of pavement is beginning to be used more in the U.S. for various uses. Porous pavement reduces impervious areas, recharges ground water, improves water quality, and eliminates the need for detention basins.

Picture 3: Grid-Brick pattern allowing water to drain into ground

Community Involvement

In many ways the community is the primary stakeholder during a flooding event. Their homes, businesses, and environment are damaged and so it is necessary for people to be involved in the decisions that are made and to be aware of the system in place to help them. It is an essential to have public awareness of their environment and knowledge of how flooding can effect human health and community stability. A lot can be done to increase the respect of what it takes to prevent and manage a flood event in both Germany and the United States. One of the best ways to increase community involvement and awareness is to increase accessibility of technology and planning to the public. By involving them in the process, they will be more willing to put the necessary funds needed toward flood prevention in their own communities. Increasing community involvement can also lead to more support of costly modern management actions such as the web-base GIS and DEM systems. Finally, involvement will enable citizens to be the primary responders in the case of a flood event and know how to best protect their homes and communities.

Flood Conclusions

There have been frequent increases of flooding in both Germany and the United States in the past 25 years. This can be attributed to many factors shown statistically such as increased population in flood plains or old structural measures that have not been renovated, etc. Increased flooding could also be due to global warming trends giving way to more frequent severe weather patterns such as hurricanes, etc. Whatever the cause, there is an unquestionable need to implement better managements systems, better technology, more sustainable development, and accessible flood prevention measures. In Europe, over the past several decades there have been improvements made in river basin management. There are still many challenges in the area of urban land use versus restoration of nature conservation and shipping interest when it comes to river management. Water management, land use regulations are important to preventive measures. Taking advantage of the latest and greatest

in GIS and hazard mapping will able primary decision makers to have the most up-to-date information and delegate the needs of the community during a flooding disaster as quickly as possible. Extreme flooding can be eliminated simply by implementing more sustainable techniques in flood prevention. This can be done by reducing the amount of development in floodplain areas or trying to find better ways for water to naturally absorb in the environment without the increase of structural measures. Finally, community involvement can increase support for better flood prevention and management, as well as make citizens more aware of how to protect themselves in case of a catastrophic flood.

Undergraduate Research Program

This undergraduate research project was conducted at the University of Applied Sciences Magdeburg-Stendal (FH), Germany and the Institute for Water Management and Ecotechnology during the summer of 2006. It was possible because the student's home campus, Indiana University-Purdue University Indianapolis (IUPUI), values undergraduate research, therefore setting aside funds in order for students to take advantage of the study abroad undergraduate research opportunity option to the GO GREEN course.

This particular undergraduate research program is an option to a one week study abroad course in Germany that focuses on sustainability, globalization, and German culture. This course was originally designed for engineering and technology students, however was open to all IUPUI students. The course is titled, GO GREEN, Green Organizations: Global Responsibility for Environmental and Economic Necessity, is interdisciplinary exploring the areas of sustainable design, engineering, manufacturing, technology, and leadership processes implemented and maintained in business and industry for the purpose of being environmentally responsible, cost effective, and socially responsible. GO GREEN students have an option to apply for an undergraduate sustainable research project. Because of its success, the GO GREEN project has been awarded $20,000 for the past 3 consecutive years from the IUPUI Office of Undergraduate Research to distibute to GO GREEN students applying for reserach projects. Students can receive $2,000 to $2,500 to offset their travel and living expenses in Germany while conducting their research. This particular study abroad and undergraduate research program completed its fourth summer in 2006 and it served total of 32 study abroad students of which 17 students conducted undergraduate research projects. The course has 17 partners, 13 of which are German.

The GO GREEN program has roughly 10 German industries, universities, and municipalities partners that have agreed to host undergraduate students for the purpose of conducting a sustainable research activity. So far, the majority of these students have chosen to do independent research projects or projects with our partner at the University of Applied Sciences at Magdeburg. Sustainable areas to choose from at this location are green materials, renewable energy and water management. The faculty at Magdeburg place students in active research projects among their research associates while being supervised and mentored by German faculty. This type of undergraduate research set-up has been very successful for the students who have opted to add this to their sustainable study abroad course.

The GO GREEN German partners are critical to the success of this undergraduate research program. The program would not be possible without their support and mentoring talents. Therefore, it is vital to stay in touch with the faculty and to be involved in the total process of the student's project. This program uses two mentors, which is key to its success. Each

student is assigned a German mentor and an IUPUI mentor. The IUPUI faculty mentor keeps informed of what the student is doing while they are in Germany working on their projects. These undergraduate research projects are different than a normal on campus project. First, the subject matter of these projects is generally new to the student. In addition, most of the students who take the GO GREEN class have never been exposed to sustainable development. Thirdly, these students generally have not worked in the field they are doing their research. So the area is brand new and therefore the expectation in the research work is slightly lower, however, the knowledge gained in the area of sustainable development is maximized and therefore compensates for the lack of the subject matter.

It has been the experiences of the faculty involved in these endeavours that the partners have been eager to showcase their best practices, educate students about sustainability, and, in most cases, permit students to be involved in field based research [5]. Students that extended their experience into the research realm broadened their education much beyond the typical international field trip so common to many campuses around the world. The content herein serves as a testament to the value of this multifaceted experience [6].

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