Evidence for human impacts on downstream flood risk

Environment, Disaster

Evaluate the evidence for human impacts on downstream flood risk in rural catchments in temperate regions. Before we can evaluate human impacts on flood risk we must first establish what is meant by temperate regions and also rural catchments. Temperate regions are generally regarded as lying between the Tropic of Cancer and the Arctic Circle or the Tropic of Capricorn and the Antarctic Circle and therefore rivers investigated in this essay will fall within these parameters.

Rural catchments are slightly harder to define, as today very few large rivers do not have some form of urban development within their catchments area. In this essay a river that is still in a predominantly rural catchment will be discussed even if there are areas of urban land within the catchment. Humans impact on flood risk falls into one of two categories. The first is deliberately and directly, through floodplain restoration, construction of dams and channel rehabilitation and all of these have fairly obvious positive effects on reducing flood risk.

However it is when humans indirectly affect the flood risk, throughdeforestation, land use change andclimate change(which all have a negative effect on flood risk) that there is less certainty into the extent of the impact that humans have. Overall though it is clear that human activity has resulted in ‘ major changes’ (Goudie, 2006) in downstream flood risk in temperate regions and rural catchments. The most obvious way in which humans impact downstream flood risk is through direct adaptation of the river itself and this is also arguably also the most important way in which humans can have an impact on flood risk (Mrwoka, 1974).

Damming is probably the most widespread example of how humans seek to control peak flows on rivers and the construction of dams in the UK has led to significant decreases in flooding. The reservoir created on the River Avon occupies 1. 38% of the catchment but reduces peak flow by 16% and even more impressively the reservoir on the Catcleugh in the Cheviots occupies 2. 72% of the catchment and reduces peak flow by 71% (Petts and Lewin, 1979).

The creation of dams clearly reduces the flood risk overall, however, dams have a much smaller effect on rare flood events of high magnitude, due to the fact that there is a finite amount of water a dam can hold during times of high, prolonged precipitation (Goudie, 2006). On the River Avon the ratio of pre-dam discharges to post-dam discharges is a mere 1. 02 in a once-in-10 year event (Petts and Lewin, 1979). However, despite this, man's construction of dams still has a large impact in reducing peak flood and therefore flood risk in downstream catchment areas.

Floodplain restoration is another example of humans deliberately impacting on flood risk. It has been calculated that the flood reduction function of 3800 hectares of floodplain storage on the Charles River, Massachusetts saved US$ 17 million worth of downstream flood damage each year (US Corps of Engineers, 1972). Restoration has taken place on the River Cherwell between Oxford and Banbury. Here the embankments were removed and the channels restore to their pre-1900 dimensions.

As a result of the rehabilitation of the channel peak flow was reduced by between 10-15% and the embankments which had been removed were shown to have been increasing peak flow by between 50-150% (Acreman et al, 2003). This clearly shows the extent to which humans can actively work to reduce the flood risk in a rural catchment area, and shows how important the role of floodplain restoration and channel rehabilitation is when reducing peak flows. A prime example of human activity indirectly affecting flood risk patterns is through deforestation.

The principle here is that by removing vegetation, you remove the capacity for a significant percentage of precipitation to be intercepted by the vegetation and then evaporated before it reaches the stream. Therefore, if humans remove the vegetation in a catchment area this can increase run-off and therefore flood risk. An experimental study was conducted in 1910 to investigate the extent to which vegetation coverage affected peak flow in Colorado. Stream flows from two watersheds of approximately 80 hectares in size were compared over 8 years, before one valley was clear-felled.

The catchment area which had experienced clear felling experienced 17% greater annual flow and also significantly higher peak flows (Goudie, 2006). In 1998 the Yangtze River experienced its worst floods for over 40 years, with high water remaining in some areas for 70 days. Although the precipitation over that time period was extreme, the extent of the flooding (which caused over $20billion in damages) has also been linked to the widespread deforestation that had taken place upstream of the floods.

In 1957the forestcoverage of the river basin was 22% but by 1986 this figure had been reduced to 10% (Yin et al, 1998). Despite this, it has been argued that during times of prolonged rainfall, vegetation loses its ability to reduce peak flow as there is a finite limit to how much water vegetation can hold. A study on the Yangtze showed that under 90mm of heavy rainfall, surface run-off was 65mm in forested areas and 35mm in non-forested areas and therefore the forest does not retain more run-off (Cheng et al, 1998) and therefore flood risk is no greater.

However, there can be no doubt that deforestation reduces seepage losses and therefore increases the convergence of seepage water and that deforestation increased the seriousness of the flooding that the Yangtze experienced in 1998 (Yin and Lee, 1999). The type of vegetation in a river basin can also have an influence on flood risk, and human activity can indirectly affect this. The principle here is that some types of vegetation retain more water than others and therefore their presence reduces flood risk.

The catchment area of the Coweeta River in North Carolina was converted from deciduous hardwood forest to pine (which is evergreen) over a period of 15 years, from 1940 onwards, and as a result stream flow was reduced by 20% (Swank and Douglas, 1974). However, although certain types of plant may indeed significantly reduce stream flow, the impact they have on flood risk is often considerably smaller. It has been estimated that a forest of Ash juniper trees intercept around 40% of the precipitation that falls on them each year (Owens et al, 2006).

This figure is so high as Ash juniper trees are evergreen and therefore absorb water all year round however, during storms, this figure is reduced to around 10%. This figure remains fairly similar for most vegetation during high storms. We can therefore say that although humans adapting the type of vegetation in a catchment area does have an impact on overall stream flow, the extent to which this reduces the flood risk downstream is negligible (Wilcox et al, 2006).

Land use change is another example of human activity which, although it is not done with the intention of altering river flow characteristics, still has an impact on downstream flood risk. Developing urban areas in formerly rural ones is now widely acknowledged to have a ‘ considerable’ hydrological impact, mainly thorough the ways in which it alters runoff (Hollis, 1988). Essentially this urbanization produces a tapestry of impermeable surfaces that increase run-off and therefore discharge during times of high precipitation (Graf, 1977).

However, Hollis (1975) argues that whilst urbanization may increase the recurrence interval of small floods, in rare large scale floods, land use change has little effect on the overall peak flow, due to the fact that during large storms, rural areas become saturated quickly and then behave in much the same way as urban areas. Despite this, we can still say that land use change from urban to rural does increase the flood risk, even if this increase in risk is only during smaller events.

Although we are examining flood risk in rural catchment areas, development of urban pockets in these areas must still be considered, as even catchments with only some urbanization are still more likely to suffer flooding (Wilson, 1967). Climate change is another way in which man indirectly can have an effect on flooding risk although this is a hotly contested topic, as no completely acceptable explanation of climate change has been presented before (Goudie, 2006). However, some climate models have still predicted that climate change over the next 100 years will lead to higher flood risk.

This is due to the fact that in a warmer climate, the air can hold more water, which increases the potential for latent heat release during low pressure systems and therefore increased precipitation is likely (Frei et al, 1998). A model in 2002 produced by the EU group PRUDENCE compared summertime precipitation in mainland Europe from 1961-1990 and the forecast for 2071-2100 based on the climatic predictions made in the IPCC report. This found that although overall precipitation may slightly decrease over the summer, precipitation events in the 95th percentile for intensity would significantly increase (Christensen J and Christensen O, 2003).

This would obviously increase the flood risk downstream in rural catchments. However, although climate change may, in the coming century, prove to have a significant impact on flooding, currently the topic is too heavily debated to draw any concrete conclusions on the extent to which human induced climate change increases flooding risk. We can therefore see that humans impact on flood risk in a variety of ways, some positive and some negative and all to varying degrees.

It is worth bearing in mind that in some areas man may be impacting on flood risk in both a negative and positive way and therefore having an even larger impact on the stream than would at first be obvious. The evidence for man impacting on flood risk downstream in rural catchments is often disputed; however, it is clear that man is impacting on streams and flood risk. It is worth remembering that flooding is a perfectly natural event however rivers and the floods they can potentially unleash are in a delicate balance, and man is more than capable of upsetting that balance in a variety of ways.