Abstract:

Since humans began to actively cultivate the land for food, construct structures for shelter, roads and canals for transportation, mine metals to decorate or sell, they have been altering the natural environment. It has been estimated that humans have modified over 50% of the lands surfaces available (Hooke et al, 2012). Humans have moved as much soil and rock as that moved by natural geomorphic forces, enough mass material to build a 4000-m-high mountain range, 40km wide and 100 km long (Hook, 2000). Humans are "sculpting the landscape" (Hook, 2000) through construction, mining, agriculture and urbanisation. Processes that many believe have led us into a new geological epoch, the Anthropocene.

Introduction:

This essay will discuss the concept of humans as geomorphic agents and whether we are approaching or already in a new geological epoch referred to as the Anthropocene. The term Anthropocene is *"used to signal the impact of collective human activity on biological, physical and chemical processes on the Earth system* (Zalasiewicz et al, 2011). This concept was first conceived as far back as 1873 by geologist Antonio Stoppani and again in 1926, by V. I. Vernadsky who recognized the ever-increasing impact of mankind on the natural environment (Crutzen, 2002). The term is used widely yet is still contested and is currently under review by the International Commission on Stratigraphy, the deciding group on geological timescale names and dates. The four main processes by which humans change the earth's surface are: construction, mining, agriculture and urbanisation. There is substantial evidence in favour of humans as geomorphic agents. This essay will discuss these

vehicles through which humans physically change the environment, with particular focus on agriculture as well as construction of dams and their effects downstream .

Mining:

Human activities have affected every part of the natural environment. Of the total ice free land surfaces, over 83% is considered to be under some form of human influence (Hooke et al, 2012). Direct anthropogenic processes (Goudie, 2006) such as mining have been occurring since the early Mesolithic period (Hooke, 2000). Approximations propose that a hundred times more rock and soil is removed from the Earth by mining than by all the natural erosion carried out by rivers (Middleton, 2008). In Utah USA, the copper mine there is thought to have moved more than 3400 million tonnes of material, and is 770meters deep (Middleton, 2008), an anthropogenic scar on the landscape that can be seen from space. In addition other landscapes are formed by the waste/shale deposited after removal from the earth. The very nature of mining; digging, removing and transportation of rock and soil is "*by definition a human-induced geomorphological process"* (Middleton, 2008).

Agriculture:

Humans first began to farm over 10,000 years ago and in 2007 it was suggested that 46.6% (-/+5%) of the Earth's land surface has been modified for agricultural purposes (Hooke et al, 2012). This does not indicate however that human's, given the length of time farming has been in practice, have a further 10,000+ years or over 50% free land surfaces to use. In fact the reason this land surface is not already under human influence is due to its unsuitability, that is to say its poor soils, adverse climates, steep mountains and natural forest (Hooke et al, 2012).

According to Hooke et al (2012) by 1990 *"40% of the global agricultural land area, had been degraded".* This degradation is a result of direct and indirect agricultural practices such as deforestation to clear lands for use. Deforestation, by which fire was the main tool of use, has increased soil run-off and erosion and hence enhanced sediment loads in rivers (Middleton, 2008). Studies have shown that "*Earth's agricultural land is currently being denuded at a mean rate of 643 m/m.y. This is 28 times faster than deep-time erosion rates inferred from natural processes"* (Wilkinson, 2005).

In addition soil erosion is reported to have increased the risk of flooding in the Ganges, while also causing increases or decreases in the watertable, each having different effects on the environment (Middleton, 2008). Soil run-off and erosion can result in the leaching of nutrients therefore leaving farmers no option of restoring it (Hooke et al, 2012). Humans, a geomorphic agent capable of transporting earth materials (Thornbury, 1969), have removed over 1.1 billion hectares of the worlds forest, with the remaining 3.9 billion hectares made-up of natural and human sown plantations (Middleton, 2008 citing the FAO, 2001 figures).

Urbanisation:

However deforestation is not just a consequence of agriculture. Lee and Devore (1968) suggested that "*of the estimated 80,000,000,000 men who have lived out a life span on Earth, over 90% have lived as hunter and gatherers, about 6% have lived by agriculture*" (Cited by Goudie, 2006). We feed the world's population with land that is degrading, and land being lost to urbanisation, fast. Humans since the invention of agriculture have lived in villages, towns and cities. Today the majority of the Earth's population live in cities, with a further 65% expected to be urbanised by 2040. This continued growth in urbanisation is estimated to take over 15,000km2 of agricultural land, annually (Hooke et al, 2012).

5000 years ago in Egypt construction of pyramids and canals took place, they still stand today. The Mayan monuments, built over a 1000 years ago, are still visible. Nature has surrounded these structures, and perhaps in the future human cities may one day be overgrown also: "*if construction was to stop or slows, for whatever reason, then natural geomorphologic processes will rapidly re-establish themselves, as shown by the fate of "lost" cities such as Angkor in Cambodia*" (Zalasiewicz, 2010). Nonetheless, considering skyscraper foundations can be up to 45 meters deep, made from concrete, steal and rock, exemplifies a physical stratigraphic sediment layer formed by anthropogenic processes.

This is not the only layer considered to be human made, others sediment layers are formed by soil run-off from agricultural lands (Zalasiewicz, 2010). On the whole this symbolizes a visible Anthropocene Stratigraphy layer, a new geological epoch. Urbanisation through the processes of degradation and aggradation, alter the Earth's surface. However, perhaps the greatest and most profound human geomorphic agents are the construction of dams.

Construction:

Studies have shown that there has always been long-term continental denudation, that is to say soil erosion, a few ten meters is removed every million years (Wilkinson, 2005). However human geomorphic agents, such as construction and agriculture, have increased the amount of sediment erosion. Construction alone accounts for 30% of the rock and soil transported by humans (Wilkinson, 2005).

Dam construction at first reduced the amount of sediment lost by rivers to the oceans. Dams regulate a rivers dynamic system causing them to become stagnant. Regulated rivers " *have 32% larger low flow channels, 50% smaller high flow channels, 79% less active flood plain area, and 3.6 times more inactive flood plain area*" (Graf, 2006). They

disrupt the rivers annual peak flow, inundation of the flood plains and the discharge of sediment to the oceans. Effects include destruction of the floodplains, the production of fresh fish stocks and other riparian habitats. The geomorphic processes associated with dam construction, those processes that physically change or modify the Earth's surface (Thornbury, 1969), are channel straightening and deepening, along with effects on the estuarine and associated deltas.

In America "*One hundred thirty-seven of the very large dams, each storing 1.2 km3 (106 acre feet) of water or more, alter the flows of every large river in the country*" (Graf, 2006). Studies have shown water released downstream of the dam is sediment free and capable of downcutting into the river bed, it can travel faster, leaving the river bank more susceptible to erosion (Graf, 2006). Reduced sediment loads in the river affects its ability to construct high bars and are often 52% less common in regulated river (Graf, 2006). In summary this leads to channel straightening and channel deepening, in some case rivers have downcutted below into bedrock.

An example of human induced geomorphic changes to a river, both through dam construction and deforestation to make way for agriculture, is evident on the Hunter Valley, NSW, Australia. Analysis has shown that since European colonisation in New South Wales, the Hunter River and its catchment has endured increased erosion and increased deposits on different parts of the river system over different time periods. Fryiers (et al, 2009) states that between 1881 and 1955 "*river adjustment occurred along the laterally-unconfined rivers*". However between 1955 and 1972 "*the types of adjustment shifted from erosional forms such as expansion and bend adjustment processes in the 1881–1938 and 1938–1955 phases to depositional forms such as channel contraction, low flow channel realignment and floodplain formation processes*" (Fryiers et al, 2009). The study showed that during the

"*1938–1955 phase, adjustment extended up the tributary systems on the western side of the catchment into the partly-confined valleys*" (Fryiers et al, 2009). In summary human induced adjustments to the river were still taking shape up to 1972, however the form of adjustment and where it occurred has changed over time. The result of human interaction has transformed the river both in shape and size, 56% of the river has experienced geomorphic adjustment, connected catchments being the most effected with disconnected ones either lagging or not at all (Fryiers et al, 2009).

For water from the headwater source to reach the shores in a system, connectivity must be maintained (Fryiers et al, 2007). Three forms disrupt this connectivity; buffers, prevent sediment from entering the system, barriers disrupt sediment movement in the system and blankets cover and remove storage areas for sediments (Fryiers et al, 2007). Naturally, disconnection can occur. However human erected dams disconnect the system, storing sediment in reservoirs sequentially modifies sediment loads to the ocean. Increased erosion at the coast and "*intrusion of sea water into delta areas*" (Middleton, 2008) ensues. With the risk of sea level rise in the near future, certain deltas could be lost. The Colorado River, the most densely dammed river in the USA, before 1930 carried 125-150 million tonnes of sediment each year to the Gulf of California, by 1964 it no longer carried sediment to the Gulf and water on irregular occasions (Middleton, 2008). Dams are anthropogenic geomorphic agents, changing the course of rivers and the surrounding landscape. Further downstream they are the source of sinking deltas. Delta retreat is a foremost concern and "*coastal retreat is directly influenced by the reduction of river-supplied sediment*" (Syvitski et al, 2005). Currently China has the largest amount of dams, over 18,000 and some suggest they intend to double this number. Considering that in 1994 over 2.1billion humans "*live within 100 km of a coastline, and approximately 44% live within 150 km of a coastline*"

(Syvitski et al, 2005), a drastic shift in current dam management is needed before more are built.

Conclusion:

Humans have become the dominant force in landscape modification. Through our use of dams we have shifted the natural path of rivers, destroyed deltas and associated riparian habitats, and are continuing to do so. Our mining has created cavities that are large enough to be seen from space. Bad farming practices have resulted in increased degradation of the soil: "*Degrading the land degrades our life support system. The land is an essential resource for future generations* (Hooke et al, 2012). The physical evidence suggests we have entered a new epoch, the Anthropocene. Some suggest that no substantial geological boundary has been crossed. However, the end of the Jurassic period was marked by the high levels of extinction. Today "*current estimates put the extinction rate at 100-1000 times greater than the (natural) background level*" (Zalasiewicz, 2010). Whether the Anthropocene is announced as a new epoch or not, does not imply that humans can ignore the visible geomorphic effect we have on Earth surfaces. Environmental degradation and climate change are the biggest challenges humans face today. Whether today is the "Holocene" or "Anthropocene" does not lessen the need for dramatic economic and philosophical rethinking of the way we live.

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