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DESERTIFICATION IN CHINA

Desertification in China, causes and preventive actions in modern time

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Abstract

The climatic conditions in northern China and Mongolia make these regions prone to desertification. The results showed that there is quite a lot of disagreement in this matter, as to whether it exists at all and if so what the major explanatory factor is. Some argue that the desertification is due to climatic/natural factors (almost) alone, others that human activities is the major cause, and some are in-between arguing that it is a combination. The conclusion that is reached in this paper is finally that it seems most probable that it is a combination of both natural variability and human factors, and that the desertification does exist, with a following motivation for why that is.

Sammanfattning

Klimatförhållandena i norra Kina samt Mongliet gör dessa områden benägna att drabbas av mark-försämring, vilket i sin irreversibla form ofta hänförs som ökenspridning. Litteraturstudien fokuserar på både tidigare erfarenheter, så som vad olika åtgärder har haft för konsekvenser- bra som dåliga – och även vad olika sätt att sköta marken på har medfört, samt även andra lärorika och värdefulla erfarenheter. Erfarenheter så som vad undermåliga underliggande undersökningar i området/områdena i fråga kan medföra, vilket ’the Green Great Wall’ är ett exempel på, ett projekt som inte verkar ha haft de positiva och lovande effekterna man trott att det skulle ha. Ett annat restaureringsprojekt exempel som faktiskt är tänkt att ha haft en netto-negativ effekt är en i Mauwusu Sandy Land, det ledde till att träden som planterades där sänkte grundvatten-nivån som gjorde att de dog, och i slutändan en ökad takt av ökenspridning. Detta troligen på grund av att inte tillräckligt med undersökningar blivit gjorda i dessa områden. Trenderna och förutsättningarna på en plats är ofta tänkt att gälla för den platsen, och enbart den platsen. Man kan ej applicera samma åtgärd på två olika platser utan att man kan försäkra sig om att det skulle fungera. Vilket i så fall kan baseras på till exempel underliggande forskning.

Diskussionen om negligering, om än i en underförstådd mening, och de följder det kan medföra är något som verkar vara en återkommande fråga. I detta fall i den socio-ekonomiska delen av ökenspridning så som mer resurser till landsbyggden vilket hade oförutsedda komplikationer så som expansion av städer på vad som ibland var bra odlingsmark. Att inte ha de långsiktiga konsekvensera av agerandet i beaktning. Befolkningstrycket, med nivåer högre än rekommendationerna, kan också vara/bli ett stort problem; det är relaterat till överbetning, undermåliga återtagningsförsök och annan urban aktivitet så som gruvindustri vilka alla har negativa effekter på marken. Av vilket antalet får per hektar är den viktigaste faktorn. Det mänskliga beteendet är också viktigt när det kommer till att förstå hur saker och ting kommer att utvecklas; det är en drastisk skillnad om man antar att människor är bofasta, ingen migration, och om man tar med den tekniska utvecklingen i beräkningen, och även NPP startvärdet är viktigt – vilket syns i LU-CDM modellen i Helldén (2005) (sektion 3.4.1.2).

Definitionen av vad ökenspridning är, är central i diskussionen och är därför definierad i början av arbetet, vilket även inkluderar dess historia, hur definitionen kom att bli den den är idag.

Vad framtiden kan medföra och om den ser positiv ut eller ej är också något som ses över. Det är andra fenomen relaterat till framtiden som också diskuterats, utöver de projekt/restaureringsarbeten som nämnts ovan, så som WUE. WUE verkar lovande och ett exempel är 'silt-laden' bevattning. Ökenspridningsfrågan i Kina/Mongoliet är också jämfört med hur det ser ut på en global skala; en skala som uppvisar en positiv trend, om än med stora lokala variationer.

Abbreviations

Rain-Use Efficiency…….(**RUE**)

- Net primary production (NPP)/Rainfall or Normalized Difference Vegetation Index (NDVI) / Rainfall, i.e. the proportion of available rainfall that is converted into vegetation (Gardiner, 2010).

Normalized Difference Vegetation Index……(**NDVI**)

- A measure of the plants vitality and the vegetation cover gathered from multispectral satellite images. More precisely, NDVI = (Channel 2 - Channel 1) / (Channel 2 + Channel 1), where channel 1 is the red-light region and channel 2 is the near-infrared region (Greenness of the Coterminous U.S, What is NDVI?, 2010).

Net Primary Production……(**NPP**)

- The amount of vegetation produced during a given time-frame, more precisely it is defined as the "net flux of carbon from the atmosphere into green plants per unit time" (Net Primary Productive Methods).

Water Use Efficiency……(**WUE**)

- Is in many cases defined as the plants Water Use (WU); a reduced WU leads to an increased WUE and an increased WU leads to a decreased WUE (Blum, 2005).

United Nations Conference on Environment and Development……..(**UNCED**)

United Nations Conference On Desertification……...(**UNCOD**)

United Nations Environment Programme…….....**(UNEP)**

Residual Trends……**(RESTREND)**

- The negative trends in the differences between the observed ∑NDVI and the ∑NDVI predicted by the rainfall using regressions calculated for each pixel (Wessels et al. 2007).

1 Introduction

Is desertification real, and if so, is it due mainly to natural factors or humans?
This thesis, which is mainly a literature review, will answer this question, focusing on the case study of northern China/Mongolia. This is an important and interesting topic due to the fact that it is thought by many to be a problem, and there are fears that it will be exacerbated by e.g. global warming – increasing the concentrations of greenhouse gases will (and have) probably lead to higher temperatures and changes in the precipitation pattern. Warmer temperatures lead to increased evaporation and, what might become, deteriorating vegetation (Yang et al. 2007). A change in the precipitation pattern affects farmers, especially the poorest ones which do not have any financial security or saved harvests to use when times get rough. This is true for both a dry and precipitation rich years – where yields are low. Poor farmers in these bad years are forced to borrow from either neighbor, relatives or the village (Brogaard and Li, 2005). The food production and the economic stability for the people living in regions at risk is ultimately the main essence of the topic, where both the abovementioned climate – yield matter comes into place but also Aeolian processes and its effect, off of which depletion of nutrients through erosion of the top soil layer is a major one. Beginning to understand these processes which have the possibility to affect huge amounts of people are not just important/interesting for the people that might be directly affected but for the globe as a whole – the indirect effects can have far reached consequences. Ultimately it is everyone's interest to pursue greater knowledge regarding this matter.

A change in the precipitation pattern affects farmers, especially the poorest ones which do not have any financial security or saved harvests to use when times get rough. This is true for both a dry and precipitation rich years – where yields are low; the difference between a good and a bad year can be around 2400 kg/ha compared to 380-600 kg/ha in a bad and good year respectively. Poor farmers in these bad years are forced to borrow from either neighbor, relatives or the village; the wealthier families, however, tend to demand a high interest for these loans (20 kg grain per 100 kg borrowed) while the villages on the other hand tend to charge a low interest (Brogaard and Li, 2005). The food production and the economic stability for the people living in regions at risk is ultimately the main essence of the topic, where both the abovementioned climate – yield matter comes into place but also Aeolian processes and its effect, off of which depletion of nutrients through erosion of the top soil layer is a major one.

1.2 Objective

- To elucidate, through a literature study, whether desertification in China exists and if so, try to untangle and find out the different factors' relative importance; if they even can be considered separately that is.

2 Method

This is a literature-study on published articles that are related to the objective.

3 Desertification in Modern Times, China

3.1 The Development of Desertification as a Concept

The definition for desertification used today is the one by UNCED which was formed in the state it is seen in today in the Earth Summit in Rio De Janeiro 1992, ”Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities” (UNCED 1992). However, before this definition, the concept had undergone several changes throughout the last century since its first introduction by a French scientist named Aubreville in (1949, cited in Hermann and Hutchinson, 2005 b). Back then it was defined as the spread of desert/desert-like conditions. There were however two different viewpoints regarding the causes, with one group stating it was due to postglacial climate change toward drier conditions, the other side claiming that humans were the driving force due to poor land management strategies (Hermann and Hutchinson, 2005 b), (Helldén, 1991).

Several decades on, the definition had not changed much. UNCOD´s definition implied that there were long lasting desert-like conditions which might be irreversible. Large segments of the scientific community criticized the wording/definition and called for a reformulation, and soon after, UNEP changed the definition so that it meant land degradation in arid/semi-arid areas due to human impact. The definition was, however, changed again in 1991 stating it stemmed mainly from human impact but then was changed back to its previous definition from 1991 (Herman and Hutchinson, 2005 b), (Helldén, 1991).

3.2 An Introduction to China

3.2.1 Geophysical

Northern China is thought to be prone to desertification due to the combination of its arid climate, population pressures, and land use practices. Those semi-arid areas, with precipitation of less than 400 mm annually, cover about 30 % of Chinas land area. It is far from the ocean, and mountainous (Chen and Tang, 2005). As the air ascends over the

mountains, it cools releasing precipitation. The air descending on the leeside is therefore dry **(**Ahrens, 2009).

Something else to consider is that the dry periods of the year are often accompanied by strong winds which facilitate Aeolian processes such as wind erosion. Ye and Chen (1992, cited in Cheng and Tang, 2005) notes that northern China has been getting more arid over the past decades, 1960-1990 and Shang (2001, cited in Cheng and Tang, 2005) corroborates this noting that there has been a significant rise in temperature. The rise in temperature leads to an increase in potential evapotranspiration, more explicitly a one degree °C rise in temperature corresponds to a rise of 5.25% ± 1.55 in evapotranspiration (Le Houérou, 1996) which is one of the factors explaining the increased aridity. Precipitation does, however, not follow the same trend as temperature, but instead shows relatively large fluctuations on an inter-annual basis (Li et al. 2002). The climate here, Inner Mongolia, is thought to be primarily governed by atmospheric circulation, the monsoon; this is what causes this erratic and inter-annually variable climate (Li et al. 2002). Fensholt et al. (2012), however, note that there has been a significant decrease in precipitation in eastern Mongolia and its boarder to China from 1981 to 2007.

3.2.2 Politics

In 1616-1911 during the Qing dynasty the population pressure rose and the authorities sought to find a way to feed the increasing population. They did this by encouraging people to reclaim grassland for farmland, of which three major reclamations took place during 1802-1930. This led to an increased pressure on the land which supposedly exacerbated desertification. This was further aggravated by the fact that the social-economy of northern China lagged behind, compared to eastern China, and that farming was still the major source of income. This made things worse as people desperately trying to support their families using measures which created a vicious spiral with poor farming practices and supposedly exacerbated desertification. Measures among which an overuse of land resources i.e. over-grazing, over-cropping and/or over-logging were the leading one which ultimately was a reaction to some of the state policies (an example given above) which encouraged people to go after short term gain (Zhou et al. 2010).

In 1949 China was proclaimed as the People’s Republic of China by Mao Zedong and the impact of the first communist government could clearly be noticed in the constitution of 1954. One of the first things the communist government did was to redistribute land from landlords to peasants between 1950 and 1953. This is supposed to have led to the tragedy of the commons (Compton's living encyclopedia, cited in Brooklyn College core: Chinese culture, 1995), (Feeny et al. 1990), (Zhou et al. 2010). The Tragedy of the Commons is a theory invented by Garret Hardin in 1968 which, in short, is that when the land is owned collectively and the cattle is owned privately the farmers wants to get as much out of his cattle as he can,

letting it graze as much as possible, which ultimately leads to land degradation if/when too many farmers think and act this way (Hardin, 1968).

3.3 Past Experiences

China has recognized their problematic desertification and put in subsequent actions to get it under control since the 1950s (Chen and Tang, 2005). However, actions could be spent better, they are being focused on control instead of prevention. More explicitly though it can be divided into several sub-headings.

First off the poor scientific involvement in decision-making makes it extremely difficult. To mention one important aspect in relation to this one can bring up to the surface that two areas, figuratively speaking, rarely are the same. To make a sound decision on how to deal with the ongoing degradation off land that occurs in an area you need some sort of underlying investigation. Something that works in one place can make things worse in another. So to rely on one measure that very well can be working that vast majority of times does not make it a sound decision if the underlying research is inconclusive. An aspect that might easily get sidelined is that it is not only the physical environment that rules the measures success but also cultural clashes and differences have to be considered (Martello, 2004), (Chen and Tang, 2005). Another issue, which might be truer now than ever, is miscommunication between scientists, politicians and mass media. Miscommunication in this context can mean either poor choice of wordings from scientists which then lead to misinterpretation further down the line, or that the scientists and politicians deliberately choose to exaggerate their results to get funding/some immediate actions. Historical examples of this include the dust bowl in USA in the 1930s where the Secretary of State pleaded to current President Harry Truman to exaggerate the situation as to get public funds directed in that direction (Thomas, 1997). In relation to this, it is worth mentioning a paper investigating desertification in Sudan during the late 1950s to mid-1970s by Lamprey (1975, cited in Thomas, (1997)) he found that the desertification spread in alarming rates, 5.5 km/yr. This, particularly a tangible number on the rate, is exactly what the media and politicians love because this makes it much more powerful and thus makes it easier to justify possible actions/sell more papers. However, this article turned out to be wrong; he did not fully take into consideration the natural variability. The start of the research happened to be during a wet year and the end of it was during a dry one which distorts the findings. This is bad for the scientific community as a whole and greatly lowers their trustworthiness for a time to come, how long depends on the width of the scandal. (Chen and Tang, 2005), (Thomas, 1997).

3.3.1 Socioeconomic aspect

This last part leads us on to the next topic, which is the neglect/underestimation of the socio-economic factor in relation to desertification. This is a broad topic but will nonetheless try to evolve the major parts of it. As early as late 1930s the concept of rangelands being a depletable natural source and thus have to be taken care of was recognized by the scientific world and government officials (Ho, 2000). As mentioned earlier, the perspectives from which this topic can be approached are numerous. For instance Christiansen (2009) discuss several socio-economic related topics in China and one of the things he mention is a reform that took place in the 1980s which, to put it short, meant that the countryside got more money; an increased spending power which led to an increased demand for products which ultimately led a huge building boom. A building boom that took place at the expense of what often were fertile land; this process might lead to increased pressure on other land i.e. grassland being claimed as farmland, not necessarily now but in the future (Christiansen, 2009). Buildings are relatively permanent so that fertile land is lost for a considerable time to come.
There are several different areas in China where desertification is occurring, or more accurately, where people claim it is occurring. Using the word claim due to the fact that this topic is surrounded by a lot of controversies; it certainly is not as black and white as it might seem from an outside perspective. One might think that it would be as simple as observing the landscape and documenting the changes and then draw conclusions upon that. However, as with most things, it is not as simple as that. This is perhaps foremost due to the non-equilibrium theory which, concisely, states that arid and semi-arid regions often have highly erratic rainfall – highly variable on an inter-annual bases. The vegetation follow the precipitation trend closely in these dry areas and thus grow or decline more as a reaction to the precipitation received than to human activities. The ongoing trend or state of the land might be misinterpreted if not seen in a big enough of a picture. A couple of decades might not be enough (Ho, 2000).

With that said, it can still be of interest to compare and discuss (de)similarities between the areas. There seems to be some general agreement between the different study areas; that being that the desertification developed rapidly from around the 1950s to the mid-1970s and then decelerated a bit onwards to the early 2000s at which point it started to fluctuate. This being true for most studies, no matter where in China/Mongolia they were located. However, there are exceptions, as an article investigating the desertification in a grassland in Holunbir, China, between 1975 and 2006. They found that between 1975-1984 there were stability, and, differently from the other articles, that there were a fast expansion between 1984-2000 and then, corresponding with the other articles, fluctuation going onwards. An article investigating the desertification in Ottindag also stood out, they as well found significant desertification from the 1980s and onwards and stability between 1960-1975. (Yan et al. 2009), (Li et al. 2007), (Zheng et al. 2005), (Wang et al. 2002), (Jian et al. 2009), (Yang et al. 2007 a), (Wang et al. 2007 a), (Ho, 2000).

Farmers in these regions are sensitive to inter-annual variabilities, e.g. changes in the precipitation pattern affects farmers, especially the poorest ones which do not have any financial security or saved harvests to use when times get rough. This is true for both a dry and precipitation rich years – where yields are low; the difference between a good and a bad year can be around 2400 kg/ha compared to 380-600 kg/ha in a bad and good year respectively. Poor farmers in these bad years are forced to borrow from either neighbor, relatives or the village; the wealthier families, however, tend to demand a high interest for these loans (20 kg grain per 100 kg borrowed) while the villages on the other hand tend to charge a low interest (Brogaard and Li, 2005).

3.3.2 Hunshandake Sandy Land

Yang et al. (2007) studied desertification in Hunshandake Sandy Land over the past 30 years (1975-2001) and they found that there was a distinct temporal trend; mobile dune expansion was greater in 1989 and 2001 than during 1975 and 1992. From that they draw the conclusion that it is probably more related to climate than, more or less, direct local anthropogenic factors. The latter part is to stress that the climate, such as increased temperature, might be related to anthropogenic factors seen on a more global scale. What do they have to back up this assumption then, that it is probably more related to climate? Most importantly the temperature and precipitation patterns match the observations as well as what they would expect; greater sand dune activity in the dry and warm years, and the reverse in cold and wet years with dunes being less active. This is not to say that local human factors are not important, the grazing by cattle plays an utterly important role in loosening the soil and, in some cases, even making plants (including their roots) get detached. This loosening of the soil facilitate desertification; making it easier for the wind to get to the soil (no plants hindering the wind) as well as less aggregation subsequently leading to the facilitation of Aeolian erosion, wind lifting up sand particles if the wind speed if sufficient enough (Yang et al. 2007 b).
As noted, grazing can be a contributing factor easing the progress of desertification. An estimation of its relative importance is made from observations where the trends does not correlate sufficiently well with the number of grazing cattle; even less so bearing in mind that there should be a time-lag between grazing pressure and observed land degradation. Another influence grazing has on vegetation patterns that in turn influence desertification proneness is that grazing keeps the vegetation from growing too tall. Lower vegetation is not as capable at protecting the ground from wind erosion as is taller vegetation (Yang et al. 2007 a).

These trends are highly localized, meaning that, even though climate is supposedly the major driving factor here, anthropogenic factors might very well be the leading factor in other places. Such a place is thought to be Maowusu Sandy Land where sand dunes have been reactivated due to, what is thought to be, human activities such as improper restoration practices. Among which tree planting is one; the trees depleted the ground water and

eventually died due to water deficiency which was followed by an increased rate of desertification. Another one of such improper actions aimed to restore the subjected area is seeding from the air, which was the action of dropping seeds from an airplane or such a device in the hope of it starting to grow. It did indeed grow, but the negative consequences far outweighed the positive ones seen in retrospective. The plants loosened the crust that the sand dunes had achieved over time and not only that, they also lowered the soil-moisture in the affected areas (Yang et al. 2007 a).

3.3.3 Reconnection and further development

Qi et al.'s article Temporal-spatial variability of desertification in an agro-pastoral transitional zone of northern Shaanxi Province, China (2012) discuss and evolve several prior articles in the subject but does, however, while discussing many of the major points drawn in the previous papers, fail to shed light upon points such as that the two major political actions aimed to reduce desertification might have opposite effects which was mentioned in the article by Yang et al. (2007). This underlines the importance of a wide spectrum of sources. With that said they do shed light upon both sides in the discussion, whether the desertification is due to anthropogenic or natural causes, as well as laying the ground for new angles of approach in the general discussion. The underlying articles and the discussion will be examined below, along with, in some cases, articles not mentioned in that article. They found, in correlation with several other articles that the severity of the desertified land had decreased from 1986 to 2003 but increased in width during the same period (Yang et al. 2007 a). This is thought to be due to a decreasing trend in wind speed and thus also the erosive power. There is a cubic relationship between the erosive power of the wind and the wind speed, meaning that an increase in wind speed by X leads to X^2 greater erosive power. The decrease in wind velocity was accompanied with raising temperatures and reduced amounts of precipitation in the 1980s and onwards which contributed to the development of greater areas affected by desertification, although it was not as severe as prior to the mid-1980s due to the reduction in wind velocity (Yan et al. 2009).

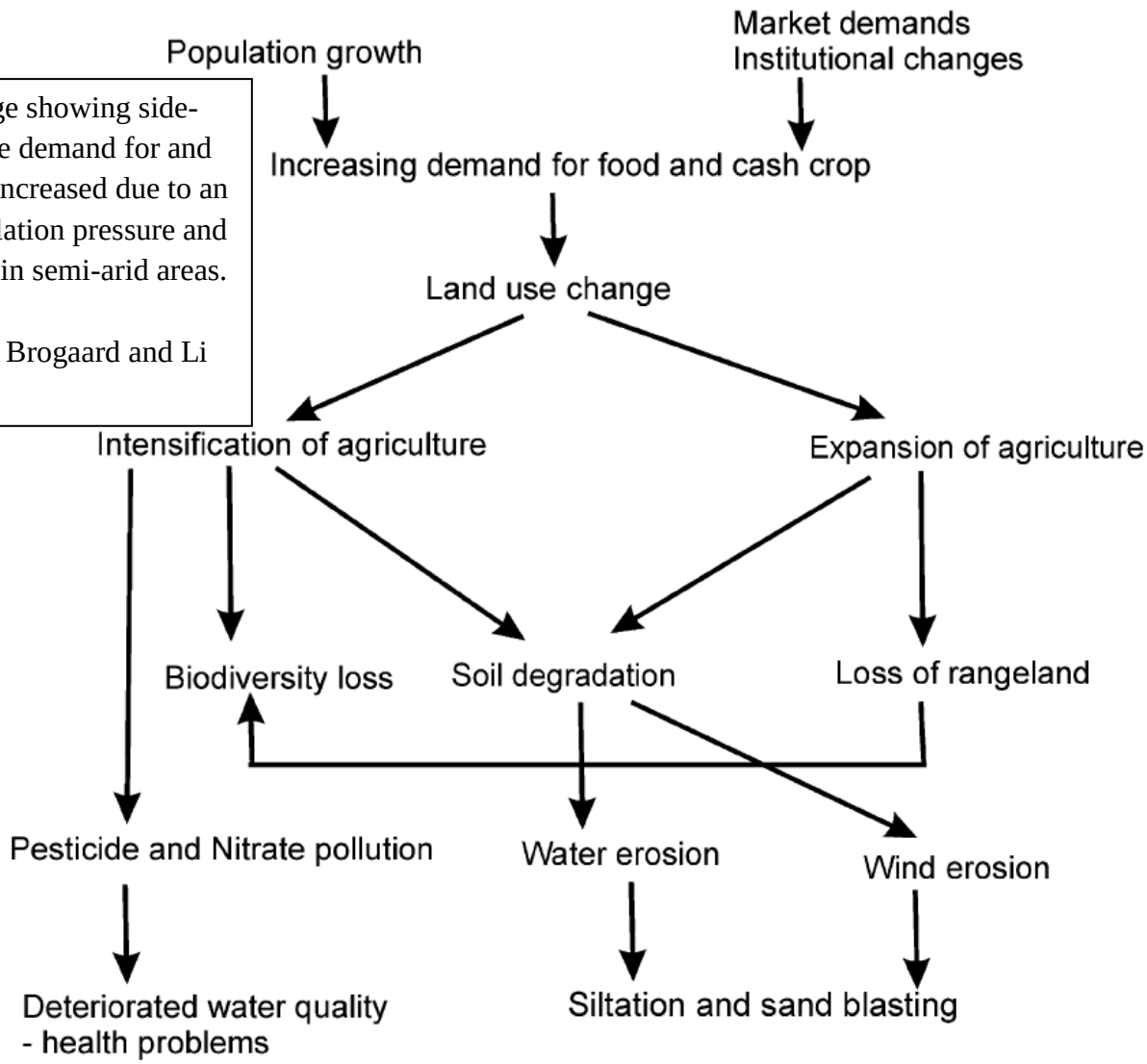
Qi et al. (2012) also mention the growing population-pressure in the area, an issue that has received attention in numerous articles such as e.g. Wang et al. (2003) and Xie et al. (2004) (cited in Zhang et al. 2008), and the negative consequences that might have on the land. Not only did the farming/grazing increase as a consequence of the increased population pressure but so did the establishment of extraction developments aimed to extract the vast resources underground, such as coal, natural gas and petroleum. A trend which leads to further development of the local economy which in turn encourage further development of the mining industry and urbanization which has a tendency to degrade surface vegetation, soil structure and spoil water resources (Qi et al. 2012). Zhang et al. (2008) investigated desertification in the Minqin Oasis, not far from where Qi et al.'s research were located, and found a recurring trend over the past 2000 years. A trend of land claimed for agriculture and then later

abandoned and then reclaimed again. A trend which might be explained by land being claimed when the conditions there are suitable, in this region foremost adequate access to water, and then abandoned when agricultural practices there are no longer feasible, again probably related foremost to water, or lack of that is. After which the land has been abandoned it starts to regenerate itself to be claimed for agricultural practices again in the future when the site is deemed suitable again, or suitable enough to be worth the hassle of relocating ones practices there, and the circle is complete. In short, they suggest that this is natural, that there is a natural trend of desertification and abandonment. Consequently if one read between the lines, that the debate about desertification, although serious, is slightly exaggerated (Zhang et al. 2008). Qi et al. (2012) also notes that the Lanzhou Institute of Desertification of the Chinese Academy of Sciences found that "…94.5% of desert expansion was caused by the anthropogenic factors, and unreasonable land use by humans was the dominant contributor to desertification in northern China", in the 1980s. (Qi et al. 2012). As well is a study by Zhu et al. (1989, cited by Zhou et al. (2010)) which found that 94.5% of the desertified land in northern China were instigated by unreasonable human activities, off of which 93.8% was related to the farmers' unreasonable economic behavior.

Besides the above Qi et al. (2012) also explore the political side of the topic, what degree of importance they play in desertification trends. Among things explored are the two major political action plans aimed to fight desertification that was employed over the last few decades. It was mentioned briefly above that they missed some key aspects here that were brought to the surface in other articles such as Yang et al. (2007). While Qi et al. (2012) talk about these incentives in an overwhelmingly positive way, Yang et al. (2007) does more or less the opposite, questioning whether there actually were any positive effects at all, seen in the long run, coming from these action plans.

Fig. 1. An image showing side-effects when the demand for and cash crops are increased due to an increased population pressure and policy changes in semi-arid areas.

Reprinted from Brogaard and Li (2005).



3.4 Present

3.4.1 Causes of desertification

3.4.1.1 Driving Factors

As can be noticed by the headings above, there are numerous factors contributing to desertification. Danfeng et al. (2005) showed how different factors were related to desertification, factors divided into several headings; demographic, land use, agriculture structure, agriculture outputs and agriculture practices. They draw conclusions and discuss these factors having the years 1988, 1992 and 1997 as starting points. In 1988, according to them, the most important indicators were: *percent area of crop ridges of plant* (TIERID) and *population density* (DENPOP), the former being accompanied by greater values for percent of *arable land of total area* (ARABLE), *number of well for irrigation* (WELL) and a smaller value for *average sheep number in pre-household* (SHPHOU). All of which contributed to less desertification. In 1992 things had changed a bit, then it was the *average electricity consumption of per rural household* (ELECON) that was the major explanatory factor for the desertification risk, which was accompanied by greater *annual average grain yield per capita* (YIEPER) and *annual average net income per capita* (INCOME) and lower SHIPHOU. For 1999 things had, yet again, changed slightly with INCOME and SHIPHOU being the most influential indicators. The common denominator over the study period was SHPHOU which has a negative influence on desertification due to sheep grazing the land which removes some or most of the vegetation which leaves bare soil. Another denominator seems to have been agriculture practices which helped to improve the agriculture output (See Appendix for table with further explanations of the terms), (Danfeng et al. 2005).

Zhou et al. (2010) discuss this as well, although in a slightly different manner. They divide the driving factors into several general sub-headings and discuss them based on bird signs with less individual numbers. That meaning that they have some numbers on the rate and progress of the desertification in total but have not attempted to put numbers on the underlying factors as the previous article did. They are on the same track as Danfeng et al. (2005), however, they describe it in such different manners that it is not that clear. They talk about over-grazing, over-cropping, over-logging which then can be seen as agricultural practices, as well as other human activities and lastly state policies. Put like this, the similarities are quite discrete and hidden, but with a stretch they are there. Over-grazing – SHPHOU, over-logging and over-cropping – WELL, ARABLE and TIERID, Other human activity – YIEPER and State policies – INCOME and ELECON. These links are not written in stone, instead they are quite loose lines between them and one factor can belong to several groups. Why all this talk about this then, why is this important? Well it is important in that way that articles in this area often draw slightly (more or less) different conclusions and thus it is important to find some common ground between articles and then try to find out where they start to go different

routes. And from that try to discuss and understand why that is; different locations is naturally one of the most important factors but there are examples of articles based in the same location who find different trends and results.

One such example involves Micael Runnström (2000, 2003) and Wu and Chi (2002); they studied the same area during the same period but draw different conclusions. One of the reasons for this might be the choice of wording and how they interpret the results. However, this does not explain everything, it might be one part of answer but it is not the whole. Runnström for example notes that generally the vegetation has increased in the area, while Wu and Chi notes that the vegetation have rehabilitated in some minor areas but that the situation has actually grown worse in most parts. It depends on how much focus Runnström puts on this area that has shown rehabilitation but perhaps more importantly, in this case anyway, is how they have interpreted the results; if they have used different models or just regarded change in vegetation and the vegetation in the start of the study differently.

3.4.1.2 The LU-CDM Model

Helldén (2005) conducted a research upon desertification trends in Naiman County in inner Mongolia autonomous region, Fig. 2., using primarily a model developed at Lund's University called LU-CDM, which in combination with underlying and contributory facts such as Satellite images and field-surveys helped testing the models trustworthiness, as well as being used for calibrating the model – more specifically - being the source for the start values of the different simulations. Three simulations with different starting values, as well as with different behavioral patterns were conducted, fig. 3., fig. 4. and fig. 5. The model is a human-environmental coupled model which "integrates socio-economic drivers with bio-physical drivers of biomass production, land degradation and desertification" (Helldén, 2005), and bases its definition of the two last aforementioned ones on the UNCED definition (see section 3.1). It does this using differential equations. The model's flaw, however, was that it had a difficult time to generate irreversible desertification.

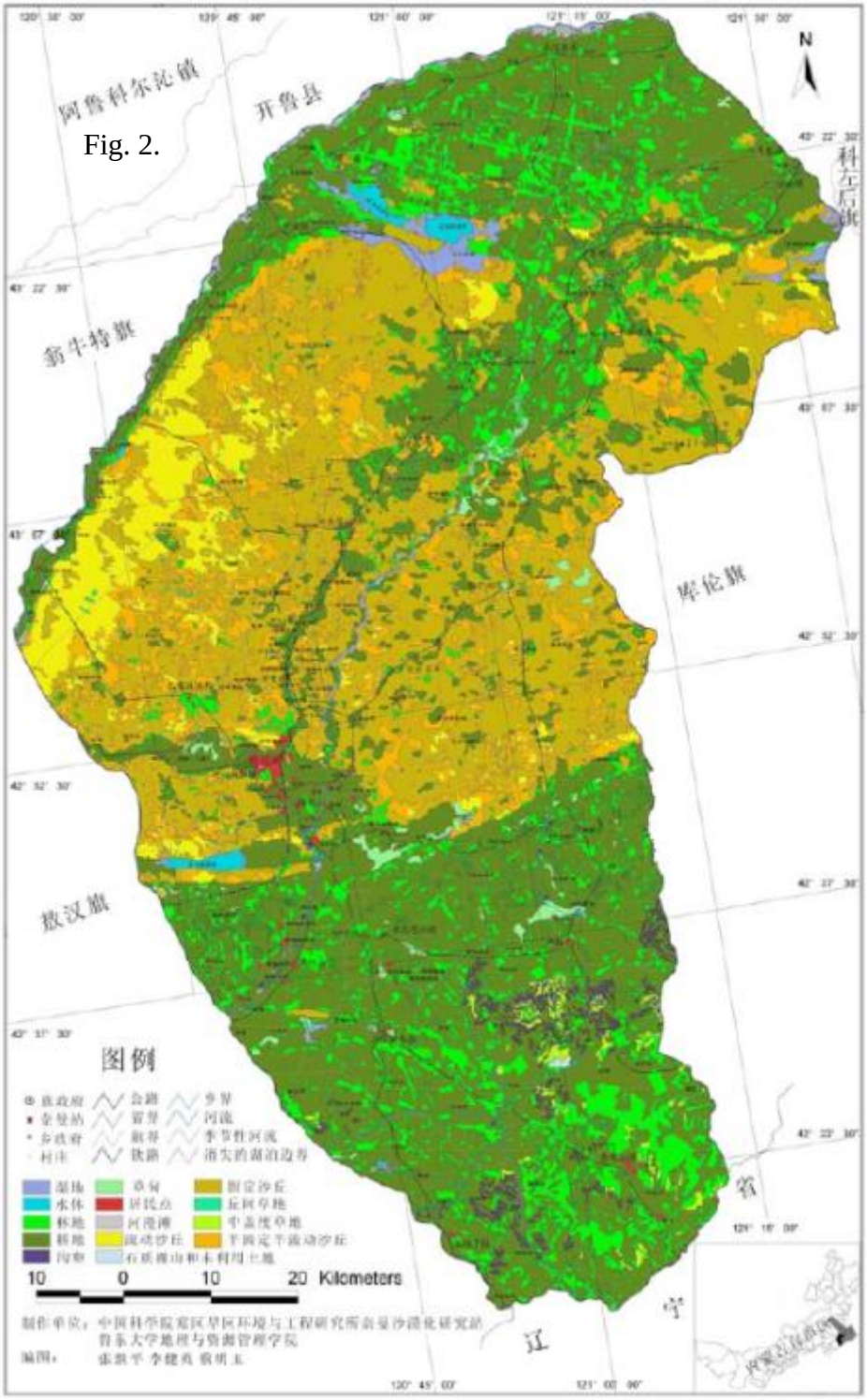


Fig. 2.
This is an image
displaying the area where Helldén (2005) conducted his research, namely Naiman county in inner Mongolia. It also displays the land-use in the area, data which was received from CAS who had interpreted air photos in 2005 (Desert Research institute, Lanzhou. Cited by Helldén in 2005). The dark green colours symbolize cultivated land on silty, clay and loss soils. Light green symbolize forest plantations. Yellow is barren sand dunes and sheets. Orange colours symbolize fixed and semi fixed dunes and sheets (Helldén, 2005). Reprinted from Helldén (2005).

All of the figures show simulations over the period 1959-2007. Worth noting as well is that the precipitation values stayed the same in all three of the simulations, thus making it possible to exclude it from the conclusions drawn from the simulations.

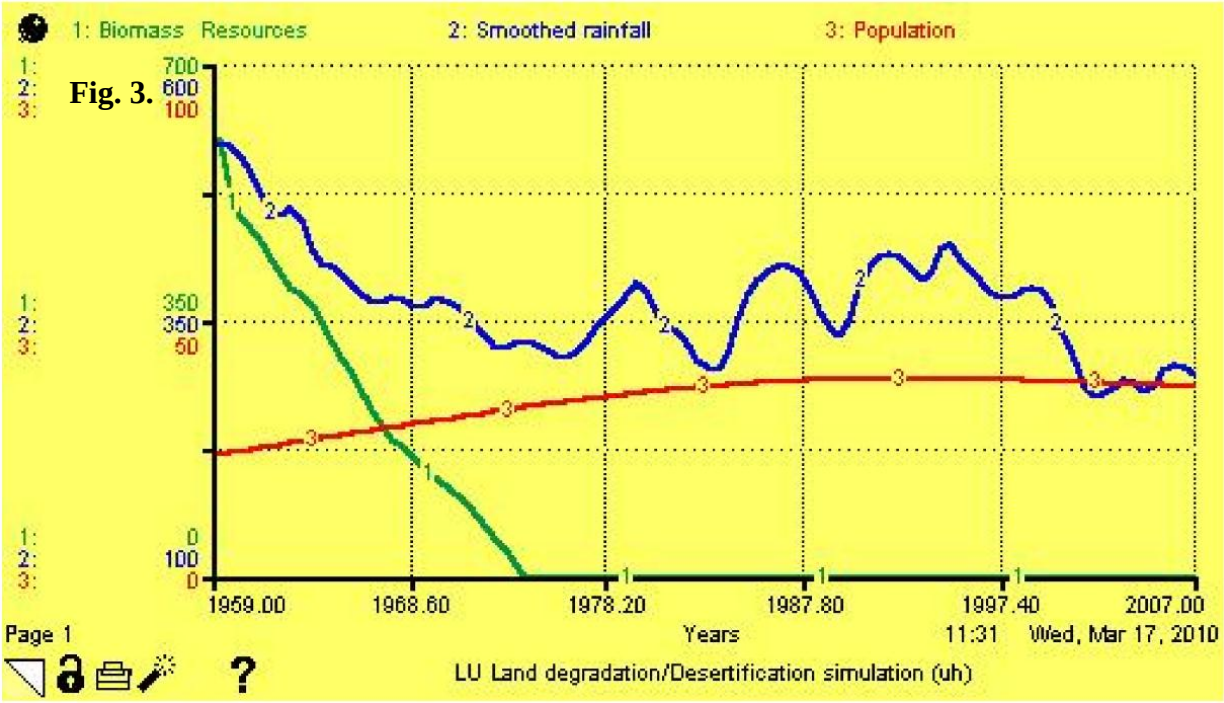


Fig.3. In this simulation no migration of people was assumed – being the behavioral pattern, with a NPP starting value of 600 tons/km^2 and for population 24 inhabitants/km^2. This, as we can see, lead to the system collapsing in the early 1960s and freefalling until it hits a NPP value of zero in early 1970s. This system is clearly not sustainable. During the same time inhabitants increase slowly but steadily until they seem to reach a top in about 1987 which was followed by a slight downward trend in inhabitants. The inhabitants were in this one relying upon imported resources to be able to survive, due to the system having collapsed and thus not being able to support themselves on locally produced products. Reprinted from Helldén (2005).

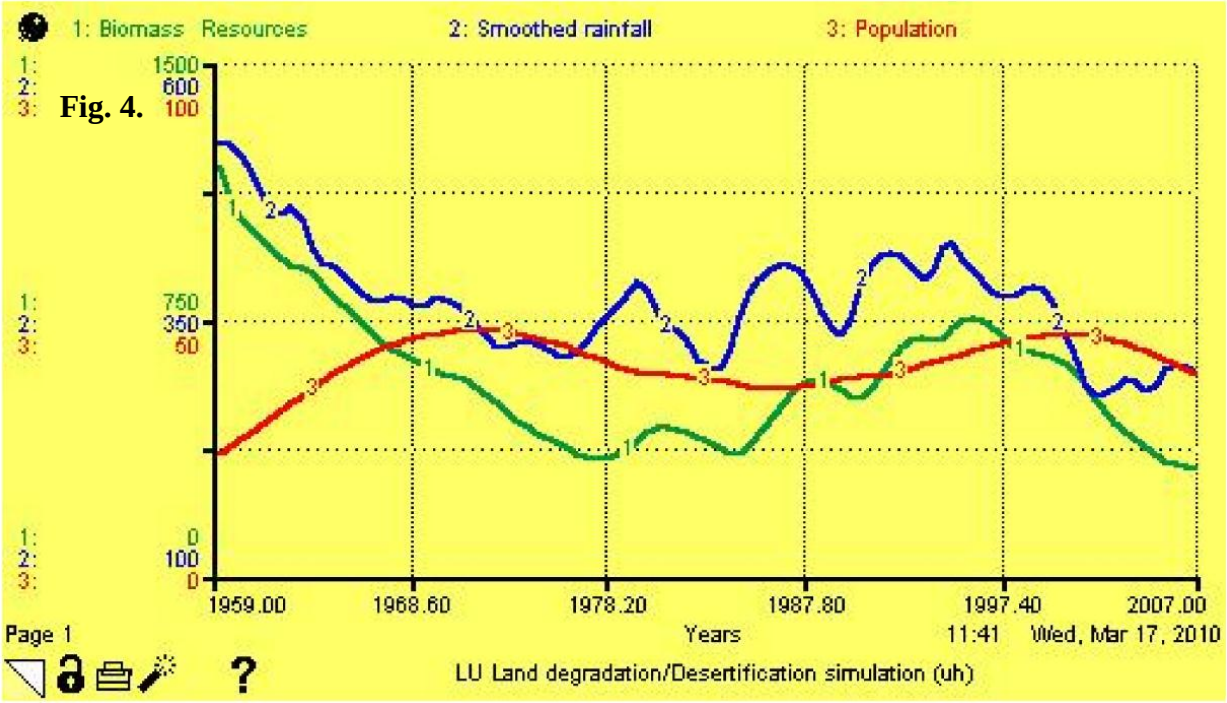


Fig. 4. Is markedly different from Fig. 1. Here the system seems to be somewhat stable after the initial falling trend, although fluctuating quite a bit. The starting value in this one is 1200 tons/km^2 – compared to 600 in Fig. 1. - and the number of inhabitants stayed the same, 24 inhabitants/km^2. Although with a slight change in behavioral pattern, here some migration was assumed. The system seems to have stabilized at around 35-40 inhabitants/km^2. The starting value of 1200 instead of 600 was chosen to demonstrate possible effects of irrigation and the technological development from 1959 and onwards. Reprinted from Helldén (2005).

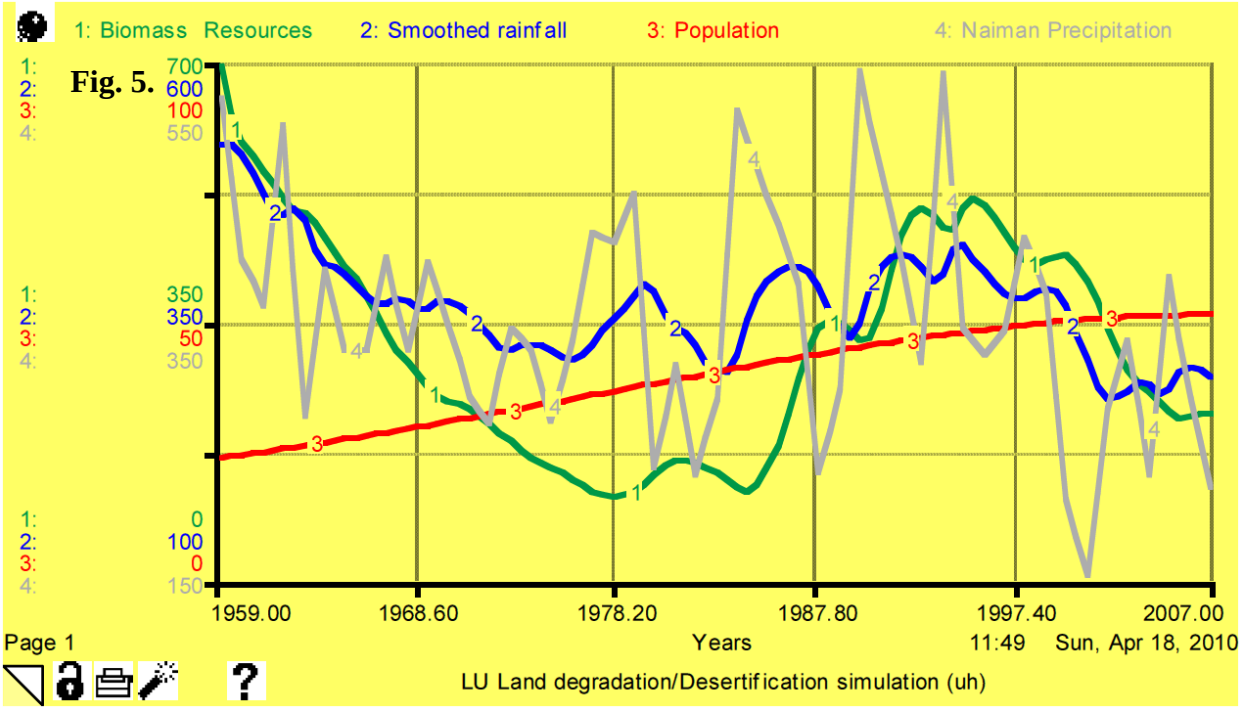


Fig. 5. The starting value of 24 inhabitants/km^2 remained the same, while the NPP value was now 700 tons/km^2. No migration of people was assumed. The system appears to be used over its limits in the first half of the graph - NPP falling steadily. This trend was turned around in the late 1980s where the system started to recover, which according to Helldén (2005) is due to preventive and rehabilitative measures being put into action. After that the system seems to be reaching a stabilized level which appears to be around 52 inhabitants/km^2. Which he also concludes corresponds with the current population pressure. Reprinted from Helldén (2005).

3.4.1.3 Side Effects of Grazing

Grazing can have severe effects on the land, off of which grasslands are considered here, and ultimately lead to desertification (land degradation). This is done in a step-wise manner, patches of degraded land starts to show up, patches which over time grow and gets linked together to grow bigger and bigger, if protective measures of one scale or another are not taken. These patches are formed through plant species tending to grow together in patches where the conditions are suitable, thus such patches form when palatable plants are eaten. However, this is not the only way in which patches appear and grow in size; the trampling by the cattle is also of major importance. Their cloves, if taking such animals as an example, loosens the top soil layer (supposedly about 10 cm), a process which might remove plant species there and expose bare soil. The bare soil is then highly susceptible to erosion. More specifically wind erosion which is considered here. (Zhao et al. 2005) Although this is true it is not as simple as that to produce highly weathered (wind eroded areas), there are numerous of factors needing to be right as well. One such is the soil-moisture, if the soil is moist

enough, more than 2.8-5.5 %, its connectivity and weight makes it too difficult for the wind to lift; the former probably being the most important one. The wind speed and timing is also of outmost importance, if the wind speeds exceeds the breaking-point at which it is able to lift sand particles from the ground, and if such wind-speeds occur during the winter when there is less vegetation cover the weathering risk is significant (Bolte et al. 2011). (Zhu and Chen, 1994; Rubio and Bochet, 1998 cited in Zhao et al. 2005), (Yang et al. 2007 a,b).

The desertification is most pronounced in the spring, the period between thawing and planting of crops; the period where the soil is bare and exposed. As been mentioned the wind depletes the soil off of its resources, but it is not only due to the direct effects the soil have, but also due to the soil being a complex and intricate web of nutrients tightly interrelated. A web which Zhao et al. (2006) along with predecessors tried to untangle. The most influential driver seems to be clay content; when there is severe erosion the clay content is significantly lowered and the clay content in turn affects several other nutrients and properties of the soil. Clay content had a significant negative impact upon pH, off of which the authors draw the conclusion that soil nutrients were negatively affected. And pH was in turn negatively correlated with soil moisture. These far-reached consequences, foremost the latter one, can partly be explained by the observation that soil coarseness increases with decreasing clay content, thus reducing the soils water-holding capacity.

3.4.1.4 Dust Storms

Tao et al. (2006) explored dust storms in Inner Mongolia between 1971-2000, analyzing 58 major dust storm events and drawing conclusions from them related to upper air and surface weather conditions. More specifically they investigated it to three different groups, trough formations, northwest current and Mongolian vortex. They found that trough formations were the most important factor accounting for approximately 2/3 (63.8 %) of the high velocity dust storms. High wind speeds are an intricate part of the formations of dust storms, and this in combination with the ongoing global warming, with significantly increased observed temperatures in the study region over the course of the last decade. That accompanied with less precipitation and greater evaporation rates it is bound to a bad combination. To be more precise, the temperature increased by 1.01 degree C in the Alxa region and by 0.96 degree C in Hunshdak (Tao et al. 2006).

Following the wind erosion trail, there are severe dust storms in China causing significant damage. Damage that can manifest itself in several ways, airborne sand particles can damage plants, berry farmland, polluting the atmosphere, affecting livestock husbandry as well as affecting power and communication systems. Tao et al. (2006), (Kar and Takeuchi, 2004). The deserts in China have been estimated to be responsible for as much as half of the global production of dust (Zhang et al.,1997, cited in Yang et al. 2007 b).

3.4.1.5 Water Availability/Issues

One major issue in northern China is the decreasing amount of water available. Kang et al. (2008) discuss this trend and measures needed to be taken. They studied the Shiyang River Basin which lies in the Northwest of China and which is the largest basin when it comes to the amount of people living there. Due to both climatic and anthropogenic factors this historical oasis is deteriorating and increasingly used over its carrying capacity, slowly and steadily moving towards the singular goal of ecological crash.

An oasis that has a history going at least 2000 years back in time is now on the verge of extinction; that is if the current situation does not change and protective measures are being taken. The net water consumption in 2000 was higher than the total resources of the basin, a use of 103 % of its capacity, and the oasis has experienced a significant reduction over the last 50 years, 5.42 x 10^8 m^3 and 0.98 X 10^8 m^3 in the 1950s and 2000 respectively. This is important from a desertification perspective in that it has brought with it, may that be directly or indirectly, an expansion of desertified land by 15 000 hm^2/year (hm^2 = hectometer, 1 hm^2 = 1 ha), and a spread of sand dunes moving at a rate of 8-10 m/year. However, the consequences are far reached, and in some cases far-fetched; due to the agricultural land expansion, especially in the middle region, there is a highly uneven use of water-ratio between the different regions with the middle-lower region ratio for example being 1.0:0.57, and 1.0:0.07 in the 1950s and 2000 respectively. In fact less and less water reach the lower region which makes people there relocate to other regions with better basis for success. This expansion of agriculture and the following expansion of irrigated land with a growing population pressure, far outreaching the recommendations of similar regions, have also lead to severe salinization; a salinization increasing from 20 400 in the 1950s to 45 800 in the 1990s (Kang et al. 2008).

China has grown rapidly and immensely over the course of the last half century, but to some extent it has been at the cost of the nature. They pour out great amounts of greenhouse gases and other non-environmentally friendly compounds as we speak, and the question is how long the rest of the world will tolerate this, China expanding at such a rate, partly neglecting the nature. However, they do have come far when it comes to politics regarding both the environment and economics. The economic reform in 1978 shows this, a reform driven through by the brave Deng Xiaping, the current communist party leader, who received quite some negative feedback regarding that proposed reform from within the party from people thinking it was too fundamental and drastic (Tisdell 2009). The reform was described as to be pursuing “socialism with Chinese characteristics” (Xiaoping 1984, cited in Tisdell, 2009). In short the economic reform has made China go from a place where the market forces were a neglectable part of the system to where they play a major role. China has at the same time

gone from a place where they had little to say in global questions to where they truly are one of the ‘big guys’.

This economic reform is discussed since it had quite a big impact on land degradation in China. One part of the reform is that instead of the land being owned exclusively by the collective, people are instead allowed to rent it for 15 year periods; although the land is still technically owned by the collective the farmer might be seen to have a greater sense of power. A quite restricted power that is, since farmers cannot decide entirely by themselves what they want to grow (Hu, W., 1997). This 15 year rental limit is highly destructive; it is not a long enough period for the farmers to want to invest money on the land so that the earnings (land profitability) would increase in the long run. Instead the farmers are persuaded to use the land as much as the can in that limited time and to get as much as they can out of it, not thinking about the lands forthcoming and the possibly next farmer who is left with an unproductive and degraded land (Hu, W., 1997). It becomes a bit like the tragedy of the commons, the farmers own their cattle privately but the grazing lands are owned collectively. Each farmer tries to get as much out of his cattle as possible, letting them graze so that they can be used for their full capability, not thinking about the lands well-being (Hardin, 1968), (Feeny et al. 1990).

Desertification/land degradation is not a local issue but has consequences reaching far beyond local boundaries. There is the economic one whose domino effects can be seen to, more or less, affect the globe as a whole. Land degradation in place X leads to less yield which then might lead to raised food prices for that affected plant. Depending on how harsh the competition is for a specific product there is also the possibility of raised prices due to farmers needing to use more fertilizers to sustain a reasonable production on their land. Dust storms are also a major problem in affected/surrounding areas. The wind erodes the top soil layer, the most fertile part of the soil, and thus depletes the land of its fertility and resources. Even though those eroded particles are dispersed to some degree to surrounding farmlands, the amount of nutrients they receive through that process is far less than what they lose (Li et al. 2004).

3.5 Outlook

3.5.1 General - Driving Factors

There is an ongoing debate whether desertification truly exists or not, or if it mostly is natural variations over time; also referred to as the non-equilibrium ecology theory (Ho, 2000), (Hermann and Hutchinson, 2005 a). One of the major issues is to find a method that separates naturally induced effects upon desertification from anthropogenic ones. Wessels et al. (2007) explore exactly this; they discuss several different methods, and ultimately try to find a method that would be applicable in situations like this, when one tries to find out the relative importance of different factors in ongoing trends. The methods they test are ∑NDVI-RUE and RESTREND (residual trends), i.e. negative trends in the differences between the observed

∑NDVI and the ∑NDVI predicted by the rainfall using regressions calculated for each pixel. They did not deem RUE (the ratio of NPP to rainfall) to be optimal for this type of question due to its strong correlation with rainfall; it merely showed the amount of rainfall and not the land degradation trend. RESTREND on the other hand were considered to be a better fit, if it was accompanied by a remote sensing and in-field investigation as to determine the underlying reasons contributing to the RESTREND value they got. To clarify, RESTREND recognize areas where there have been an increase/decrease in productivity per unit rainfall but to why this is you cannot tell for sure without investigating the area. It might be due to over-grazing by livestock or a short-term spike in productivity due to grasslands being claimed as farmland and thus possibly increasing the productivity but an increase that might be quite short-term due to the land being used over its resourced with land degradation and falling productivity as a result. (See abbreviations for further explanations).

Something that would suggest that this might continue to be a problem is the fact that these soils, arid/semi-arid soils, are often not very productive, so when desertification/land degradation is becoming an increasingly big problem the incentives to put immediate actions in to work to change the trend and/or restore the land is poor (Glenn et al. 1998).

One suggestion that is mentioned in several articles on this topic, land preservation and restoration, is the lands great natural ability to restore itself as long as it is not too severely degraded; degraded below a certain threshold. An edge beyond which the land have lost its ability to rejuvenate itself, by itself; a point which varies from place to place (Li et al. 2007).

3.5.2 Strategies to Combat Desertification

Improving the Agricultural WUE is one relatively straightforward way to lower the water-pressure on farmlands in arid/semi-arid regions of northern China. Almost all, 97 %, of the irrigated farmlands still use outdated irrigation methods such as furrow or border. This leads to them having a significantly higher annual water demand than they would have to, 7320 m^3 ha^{-1} compared to 3250 m^3 ha^{-1} for areas that use more favorable methods such as sprinkler or drip irrigation (Deng et al. 2006). According to Jin and Young (2001, cited in Deng et al. 2006) there were a frighteningly high share of the irrigated land China that did not use any water-saving measures, more than 70 % to be more precise. The rainfall use efficiency also leaves more to be wanted with an efficiency of about 55 % in northern China (Shan and Chen, 1998 cited in Deng et al. 2006), and that being a relatively high number compared to other regions such as Ningxia Uh Autonomous Region where values range from 20-60 % (Shan and Chen, 1998 cited in Deng et al. 2006). The actual amounts of grain yield achieved from precipitation is 2.3 kg/ha/mm compared to experimental sites where it was 6-12 kg/ha/mm and the potential yield being about eight times higher, 20 kg/ha/mm. This shows that there clearly is room for improvement.

Nasierding and Zhang (2009) found that there were a decreasing trend in the amount of sandy land, off of which most had become sparse vegetation, but there were also a distinct trend of

woodland becoming grassland or arable land. This latter trend lessens the stability of the ecosystem, making it more fragile, and more prone to desertification.

Mitchel et al. (2006) is an article in which they mention and evolve the side-effects of several positive actions that have been taking place lately (read recent decades), such as the 'Green Great Wall' that was initiated in 1978, silt-laden water irrigation and a resettlement project involving 74 families. The Green Great Wall or the Three North's Program is one of the largest environmental projects to date; the aim is to plant 35 million ha of trees between 1978 and 2050 across a distance of 700km in northern China. Although the project has had positive effects in aimed areas it is not a complete success. As with many things it may have negative consequences, somewhat foreseen ones such as lowered water-tables (Mitchell *et al*., 1996). Mitchell et al. (1996) seems to have been right in his prediction, the project has not been the success it was thought and is proclaimed to be; trees have died, which might be due to a lowered water table. Another thing not making it the successful story it is thought to be is that it has not targeted the most susceptible areas in most need of attention. The frequency of dust storms and the desertification rate have decreased, but this might very well be due to climatic factors, and not anthropogenic ones, such as the Green Great Wall (Wang et al. 2010) (Wang et al. 2007 b).

Another important positive action aimed at reducing the Aeolian erosive power on vulnerable land is the establishment of checkerboards. They are effectively a kind of fence built by wheat or rice straws aimed at increasing the surface roughness and in turn decreasing the wind speed. This process is done in two steps, first creating a sand barrier, which reduces the amount of sand deposited by the wind, using woven willow branches or bamboo followed by the establishment of the checkerboards. The checkerboards, or perhaps this process all together is truer, has several far reached positive implications for the local environment there. Firstly, the checkerboards reduce the Aeolian erosive power on the land making it possible for shrubs to establish there in the somewhat protected area behind the checkerboards. The establishment of shrubs in turn enables the formation of algae, lichens and mosses which increases the lands functionality. Increased functionality in that way that the dunes become fixed and fixed dunes has shown to have a higher nutrient content. However, this was a short term effect; the shrubs had difficulty regenerating and decreased over time and the plants were not able to regenerate at all on the cryptogamic crust that, ironically, they had created (Nasierding and Zhang 2009).

Silt laden irrigation is an effective way of increasing the fertility of otherwise unfertile land. This is done by using water from the Yellow River – which is known to be one of the rivers that have the highest sediment discharge globally – and using this silt rich water to irrigate for example sandy land, increasing their fertility and enabling a greater development of the topsoil (a mean value of roughly 18mm/year). This enables crops to be cultivated there and ultimately creating soils that can maintain sustainable agriculture (Nasierding and Zhang 2009). Land enclosure is another effective measure that helps downgraded lands regenerate. In an area called Yanchi the effects of enclosing fields and restricting the amount of grazing

sheep to one per 0.87 ha have been overwhelmingly positive, stabilizing that land and allowing it to re-vegetate (Nasierding and Zhang 2009). Last but not least they also talk about extraction of buried soils as an action towards reducing desertification. That is, with the help of the government creating trenches with accompanied pumping equipment, farmers leveled dunes and dug by hand out buried steppe soils. This in combination with using sheep manure as fertilizer made it possible to have sustainable farming practices there, cultivating wheat, maize, soya beans and radishes. Although the authors note that the amount of time this latter trend is seen over is not long enough to make a conclusive statement of its viability, it is, however, this far a positive developmental trend.

3.5.3 Global Trend

Fensholt et al. (2012) investigated how the major semi-arid areas of the Earth have developed between July 1981 and December 2007. They found that there were generally a greening trend for the Globe as a whole; worth noting though is that that is generally speaking, and that there are regional differences. As noted, the general trend was positive, semi-arid areas were getting greener, but some areas did show a negative trend and such areas were e.g. Southern America (foremost regions in Chile and Argentina), southern USA as well as Northern China and Inner Mongolia. Since this study is aimed at depicting the trend for Northern China and Inner Mongolia it is most suitable that that is the main focus here as well. The reason as to why those areas display a negative trend is, according to Fensholt et al. (2012), due to them being constrained by both precipitation and temperature. Worth noting is that the trend in Northern China and Mongolia were overwhelmingly insignificant, neither positive nor negative, and is thus not necessarily as bad as one might believe, just comparatively bad seen against other areas showing positive trends such as the Sahel region. The border between eastern Mongolia and China had a significant decrease in precipitation during this period, 1981-2007.

4 Discussion

4.1 Source criticism

Wesche et al. (2010) based its conclusions upon research made over just 8 years. They note that they did study the area for 8 years to be able to exclude/not be affected by inter-annual variation and medium-term trends, but that is too short of a time to be able to confidently do that when articles such as Von Wehrden et al. (2010) imply that their research might be unreliable since it is based over such a short time-scale, less than 20 years.

There are several articles that contradict each other, especially in the geophysical subject where the uncertainty is greater. This is certainly not a good thing, neither for politicians for making the right decisions or for the everyday Joe who wants to get a deeper knowledge about something or who has been fed information by the media; information that often is greatly exaggerated and possibly questionable as well. Questionable in that sense that the research has not been up for enough scrutinizing and critical reading which is what the case was with the research Lamprey (1975, cited by Thomas (1997)) published about desertification in the Sahara region. It was displayed by the mass media with a terrifying undertone meant to 'stir the pot' so to speak. However, it later turned out to be wrong; the research had been based upon faulty measures. For starters the research gave an askew picture of the situation in Sahara by starting the research in a wet year and ending it in a dry, thus not showing a fair picture but more the natural variability. But instead of drawing the conclusion that climate was the main driving factor for this change he instead accompanied it to be related mostly to overgrazing (Thomas, 1997). Articles published later by e.g. Helldén (1988) and tucker et al. (1991) (cited in Thomas, 1997) did thorough research based upon exactly the same subject as Lamprey (1975, cited in Thomas, 1997) but came to completely different conclusions. An essential aspect of the natural variability is that it varies considerably over time, such as precipitation differing from year to year and thus having varying impacts on the areas; this is precipitation alone. The key is to view the different factors in the light of what they are, which, more precisely, is the combined effect. One factor might have a neglectable impact by itself but by impacting and affecting other factors as well it might ultimately end up having a far greater influence upon an area, one that is too big to be neglectable.

A constant factor of uncertainty worth noting here in the discussion is the importance of source criticism which is maybe even more important than ever when doing a literature study, never having been in the locations where the studies were/are based, leaving me to find other ways than personal experiences to try to figure out which articles to deem as more credible and which not. This was done both by checking the underlying research (papers quoted in the papers, where possible) as well as trying to figure out who financed the research and bearing that in mind when reading it. It is also important to bear in mind that there are few financers that do not have an agenda of one sort or another, trying to let go of one's star-eyed-ness which might make one view some organizations in a light in which one has been indoctrinated to, rather than what they actually are.

Such examples are global organizations; they might have hidden objectives as well, as trying to get funds for their research and thus exaggerating more or less of their findings. Even officials cannot be trusted, as in the case of The Dust Bowl in USA in the 1930s where the Secretary of State pleaded to the then current President Harry Truman to amplify the actual state of the situation. This was foremost done to get more funds directed in that direction, but can also be used to justify ones actions/spending's in the eyes of the public.

4.2 Is there any desertification, and if so, who bears the burden; anthropogenic or natural factors?

After reading a lot of articles, taking a step back; trying to grasp the general impression in hind-sight. Doing that, a red line appears that goes through most of the research in this topic, and that red line is that there are quite widespread opinions as to what is happening and as to why that is. Some state that the desertification is in fact nothing more than mostly natural variability and that the whole matter is highly exaggerated. While the other side portrays it as a huge problem, with a dooms-day feel to it, which possibly is going to grow out of control unless right and immediate measures are put into action.

It is often a difficult task to try to determine who is closest to the truth or whether perhaps both are right in parts of their line of thinking, and that a golden middle line is what is closest to reality. One also has to consider the location, a factor which is of outmost importance in most geological and ecological research, and so also here - when it comes to desertification. Bearing that in mind, the location, there is one article supporting the theory that desertification has grown worse; Kang et al (2008). They discuss the state and future of an oasis in China, an oasis that has a history going at least 2000 years back, and concludes that it is on the verge of extinction. Who is to blame for this then, is it anthropogenic or climatic factors or a golden mix between them. Well it is not easy to answer, the basin have survived for over 2000 years, that including climatic variations over time, and is now facing what might become a dull future, with Lake Qingtu being an utterly tragic scenario. Once a flourishing lake, in modern times a dried up tragic and frightening memory. The climate is most probably a highly explanatory factor in the equation, with factors such as significantly increased annual temperature and an overall increase in crop evapotranspiration, but also an decrease in annual precipitation (with local variations). Human activity is certainly not neglectable in this discussion, factors such as deforestation and over-grazing reduce the water storage and the conservation capacity in the soil which leads to higher spatial variation in river flows and reduced runoff in the dry periods (Kang et al. 2008), (Fensholt et al. 2012).

4.3 General outlook

Fensholt et al. (2012) found that the global NDVI trend for semi-arid areas on Earth were positive, they were getting greener. But with that said, the trend for northern China and Mongolia were not significant enough to be able to draw any conclusions from that area. In this discussion, although northern China and Mongolia is the main focus of this study, it might be useful – for the sake of the debate – to depict and draw parallels to the global trend as well, although in a short and concise manner. Hutchinson and Herrmann (2005 a) supports this view, they note that there is an ongoing greening trend in the Sahel region. Helldén and Tottrup (2008) support this as well noting that there is a general greening up from 1982 to 2003.

It is of outmost importance not to generalize areas; what works in one place does not necessarily work in another place, although they might look similar at a first glance. The importance of underlying research is something that is in many cases neglected. Yang et al.'s (2005) article, in which they discuss a restoration scheme, is an example of just this; plants were planted over a huge area across China as a soil stabilizing measure. However, the project did not go as planned, the trees did grow, at first, but they slowly and steadily used up and lowered the ground water which ultimately led to them dying. Now the area was left with no/minor increase in vegetation or even a decrease, at the same time as the ground water table had been decreased as well as decreased soil moisture, making the land even more unable to support any vegetation. The lowered ground water table is also something that ought to affect people living in these areas relying on water from wells; less water in wells – harder to, for starters get water just for direct personal needs such as drinking water, and secondly less water for e.g. agricultural practices.

5. Conclusion

The conclusion reached in this paper is that there is desertification; however, the negative side of the debate has a tendency to exaggerate, willingly or unwillingly. The conclusion after a lot of articles in this area have been read is that natural variability is the most important factor in the equation but that anthropogenic factors can and do make things worse. This is mostly for China and Mongolia but there is, however, a positive greening trend globally speaking when it comes to arid/semi-arid regions. The main arguments for desertification and/or that things are getting worse are based on local degradation such as the historical oasis being on the verge of extinction and that once desertification becomes increasingly more felt, the incentive to put protective actions and measure into place on these often unproductive lands is poor. The other side of the matter, the side that claims things is not that bad, uses e.g. a global view (such as fenholt et al. 2012 and Helldén, 2008) which states that there is an overall global greening trend for the semi-arid regions, but another argument used by this side is the lands great ability to rejuvenate itself (Li et al. 2007). So to tie back to the original objective then:

- To elucidate, through a literature study, whether desertification in China exists and if so, try to untangle and find out the different factors' relative importance; if they even can be considered separately that is.

Desertification exists, and its localized impacts is a serious problem for those affected, however, seen on a more global scale there is an overall greening trend which leads us to believe in a bright future. So all in all, the localized effects of desertification are something that should not be underestimated but the global trend is bright and promising.

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Table 2
Basic information of variables included in the multiple regression analysis

Group	Variable	Explanation	Unit
Demographic	NUMHOU	Rural household number	Number
	DENPOP	Population density	Individuals/km^2
	PERRUR	Fraction of rural population	% of population
	PERLAB	Percent of agricultural labor force in rural population	% of rural population
Land use	ARABLE	Percent area of arable land of total area	
	ORCHAR	Percent area of orchard of total area	
	FOREST	Percent area of forest of total area	
Agriculture structure	PLANT	Area of crop planted	ha
	GRAIN	Percent area of grain crop planted in PLANT	
	CASH	Percent area of cash crop planted in PLANT	
	DENSHP	Sheep density	Individuals/km^2
	SHPHOU	Average sheep number in pre-household	Number
Agriculture outputs	YIEGRA	Average grain yield per unit	kg/ha
	YIEPER	Annual average grain yield per capita	kg/individuals
	INCOME	Annual average net income per capita	RMB/individuals
Agriculture practices	WELL	Number of well for irrigation	Number
	TIERID	Percent area of crop tied ridges of PLANT	
	FERMIN	Average mineral fertilizer consumption per unit	kg/ha
	PERIRR	Percent area of crop irrigated	
	ELECON	Average electricity consumption of per rural household	kW h/individuals

7. *Appendix*

Table 2. A table showing the different terms discussed in section 3.4.1.1 and their respective explanations. Reprinted from Danfeng et al. (2005).

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