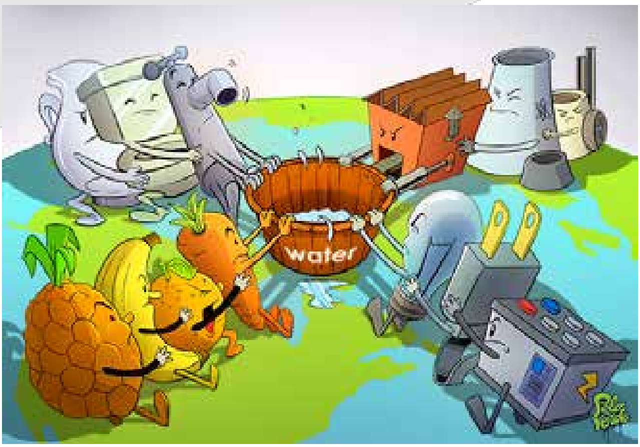
International
Institute of
Social Studies




# Water, Land and Farmers along the Silk Road

Valedictory lecture Professor Max Spoor

21 June 2018

Erasmus University Rotterdam

Author drawing: Jesus Felix-Diaz

# Water, Land and Farmers along the Silk Road

Valedictory lecture
Professor Max Spoor
21 June 2018

Professor Max Spoor is Emeritus Professor of Development Studies, associated with the Political Ecology (PE) research group of ISS, which investigates the ways in which resource scarcities are created and contested, particularly in contexts of unequal access, poverty and social exclusion.

# Water, Land and Farmers along the Silk Road

Valedictory lecture Professor Max Spoor; 21 June 2018

Farmers and rural households in particularly semi-arid regions are continuously confronted with water stress, which can be defined as the gap between the availability and withdrawal of water resources, mainly for agriculture. Water stress[1] will likely increase until 2050 and even more so until 2100, depending on whether temperature rise can be contained between 1-2 $^{0}$C. If not, the increase will be higher (IPCC, 2008). What this means in particular for agriculture, food production and the livelihoods of hundreds of millions of people will be analysed in what follows. Special attention will be paid to Central Eurasia, the region known for the ancient (and recently revived) Silk Road.

1 Most water stress indicators (or indices) use averages (for a country, a region or a water basin). There is an absolute water stress index that is also often used:

| | |
|---|---|
| >1700 | $m^3$/capita/annum: no stress |
| 1000-1700 | $m^3$/capita/annum: stress |
| 400-1000 | $m^3$/capita/annum: scarcity |
| <500 | $m^3$/capita/annum: absolute scarcity (Ruess, 2015) |

But more helpful (although still based on average data), is to compare withdrawal, annual runoff and water requirements:

WSI = (withdrawals)/(MAR - EWR)
WSI = water stress indicator
MAR = mean annual runoff
EWR = environmental water requirements
When: WSI > 1 water is over exploited
0.6 =< WSI < 1 water is heavily exploited
0.3 =< WSI < 0.6 water is moderately exploited
WSI < 0.3 water is slightly exploited

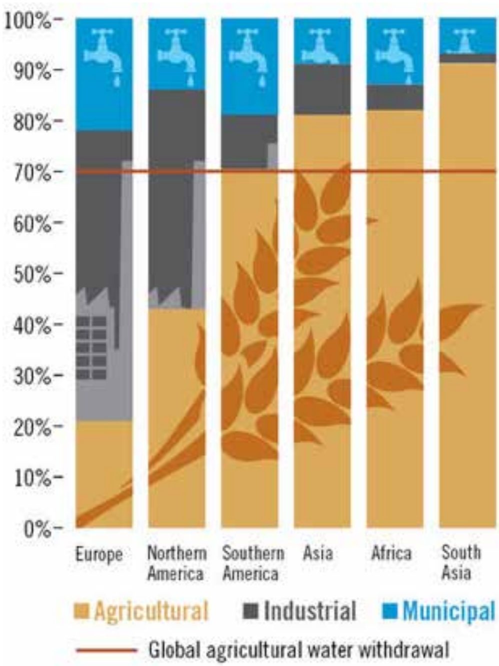
Schlosser et al. (2014) even add an additional category, namely WSI => 2, indicating extreme overexploitation.


According to the influential study by Bates et al., also known as IPCC (2008) Technical Paper IV (Climate Change and Water), some regions will have more rainfall and others less. However, they also conclude:

> Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits (high confidence). By the 2050s, the area of land subject to increasing water stress due to climate change is projected to be more than double that with decreasing water stress (IPCC, 2008).

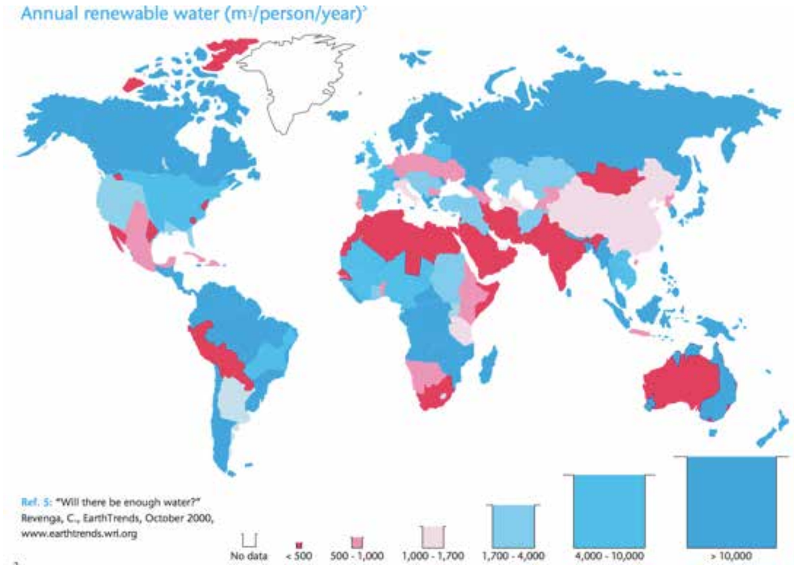
That is preoccupying, as most freshwater[2] is used by agriculture, for cash crops and food production. The rough figures tell us that 69 percent is “consumed” by agriculture, 19 percent by industry, and only 12 percent by households (www.globalagriculture.org).

2 Prof. Arjen Hoekstra from the University of Twente has coined the differentiation between ‘green’ water (rainwater used on the spot), ‘blue’ or freshwater (from rivers, lakes and groundwater), and ‘grey’ water (to dilute polluted return flows).




We are talking about the "use" of water. However, this "consumption" does not mean the water disappears. As energy, it remains but is transformed, for example into vapour (by plants), in location, in aquafers, or in quality (polluted, salinized). The availability of water is highly unequally distributed (see UNDP, 2006, with countries like Canada having 90,000 m3/capita and Yemen only 200 m3/capita).

In the industrialized world, relatively more water is used by households and industry, and less by agriculture. In Asia and Sub-Saharan Africa the share of agriculture is higher than elsewhere. However, agriculture in developing countries has become more dominated by corporate companies, and food and other agricultural commodities are exported to the industrialized (and BRICS) countries, where consumers "use" large quantities of water originating from developing countries, through what is defined as virtual water trade (Mekonnen and Hoekstra, 2011), As a consequence, access to that water locally has become even more unequal.




A milestone in our understanding of how crucial water resources are was the 2006 UNDP Human Development Report, which suggested that looking at availability of water only in absolute terms was not sufficient, and that access to water (and sanitation) was much more important. While the report referred to "beyond scarcity", UNDP did not mean that there was no longer any scarcity, but that we should look beyond indicators of average availability. We need to focus on water inequality, similarly to how we look at food production and inequality in access to food (as shown by Sen, 1981).

Returning to the key issue of water stress, this is rising in various parts of the world, in particular because of the increase in freshwater withdrawals for agriculture.


The water stress indicators mentioned above document a growing gap between the availability and withdrawal of (fresh)water resources for agriculture, industry and households. However, this largely abstracts from issues of access, unequal power relations and dependency on river water (or even aquafers) that are physically beyond the borders of the regions or countries involved.

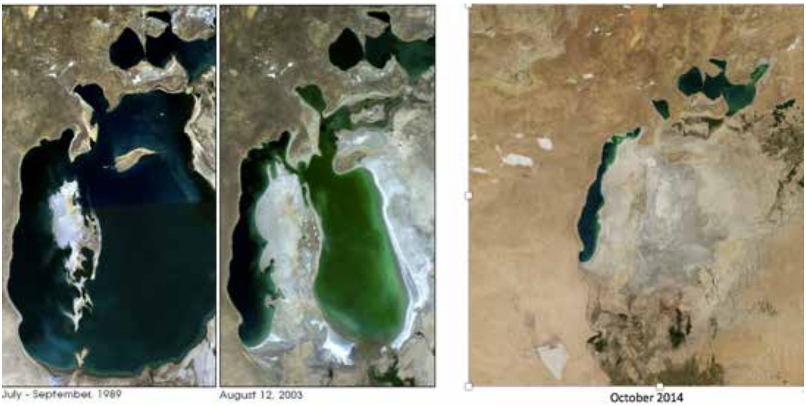
Central Eurasia is one of the regions that will be most affected by the expected increase in temperature in this century. This semi-arid region, known for the ancient Silk Road, is broadly defined as including what is now post-Soviet Central Asia, northern Afghanistan, western, northern and north-east China, and Mongolia. As early as 2006, our research group organized a conference at ISS focused on this region. The conference, which we entitled "The Last Drop" brought together scholars from various countries within and outside the region.[3]

3 This may not have been the best title, as it again focuses on absolute scarcity, diverting attention from distribution, access and power relations relating to water. However, when we published the book with the conference papers (and a number of additional commissioned ones) we no longer used the title, and our introductory chapter indicated that, to understand water inequality, water distribution, access and potential conflicts about water, we have to "follow the water" (Arsel and Spoor, 2009).


My own interest in issues of water, land and farmers in that region had already been growing long before that time. It began during one of my early visits to the Soviet Union, in particular the Uzbek SSR, in 1980. In those days, there was an ambitious and possibly disastrous plan to reroute the Siberian rivers Ob, Yenisei and Lena through the Kazakh desert into Uzbekistan, to sustain cotton production. I saw for the first time the cotton complex with large-scale kolkhoz and sovkhoz farms producing the "white gold". Soviet scientists had the unfortunate idea that more blue water would be the way to save the Aral Sea, transported southwards through huge canals rather than "spilling" it into the Arctic Ocean. However, the use (and misuse) of water for cotton irrigation should be seen as the cause of soil degradation, desertification, upward moving mineral flows and increased secondary salinization. More water, often used to leach the fields, would not have solved these problems.

From the 1990s (Spoor, 2012), after the collapse of the USSR, many trips to this region followed, particularly to those areas that had been "developed" in the 1960s (for example, during the "virgin lands" campaign in Kazakhstan) or in the 1970s in the south of Uzbekistan (such as Kashkadarya). Furthermore, I did fieldwork in the Fergana valley, where conflicts about land and water resources regularly erupt, and are fought out violently under ethnic banners (Uzbek, Kyrgyz, and Tadjik). It was – and is – a complex region, where newly independent countries took power over "their" water and land resources, often resulting in conflicting interests, in particular between upstream and downstream areas.

Back in the early 1990s, I wrote that in two decades the Aral Sea would probably have shrunk to several small separate parts (Spoor, 1998). There was still some hope that the hundreds of conferences on the topic, and the enormous amounts of money donated to the issue, would actually help to avoid what is now referred to as the world's worst environmental disaster. Unfortunately, they did not. In actual fact, as was flashed in the news in 2004, "we" did save the Aral Sea, when the Kazakh government, with the financial assistance of the World Bank, completed the construction of the Kokaral dike. The dike separated the "small" northern from the much larger (and shallower) southern part of the Aral Sea, lowering its salt content and improving the fish stocks, by exclusively using the water of the Syr Darya. However, this was a highly partial "solution", which left 90 percent of the sea in shambles.




Many agricultural areas along the main rivers in the Aral Sea basin suffer from soil salinization, which forces farmers to leach their land, using even more water, to enable them to plant crops, mainly cotton. If they cannot diversify, and no off-farm employment is available, they are caught in a "salinity trap"[4], or are forced to migrate. This pressure might be aggravated in the future when, according to the IPCC (2008) climate change models, temperatures in the Central Eurasia region will rise faster than elsewhere.

4 I am borrowing this term from Nazilakhon Mukhamedova and Martin Petrick (2018), 'Coping with constraints: Crop diversification and soil salinization in two Central Asian cotton regions', a paper presented at the 'Soil degradation and shifting agrarian orders in Central Asia' workshop, 5-6 February, University of Tübingen.

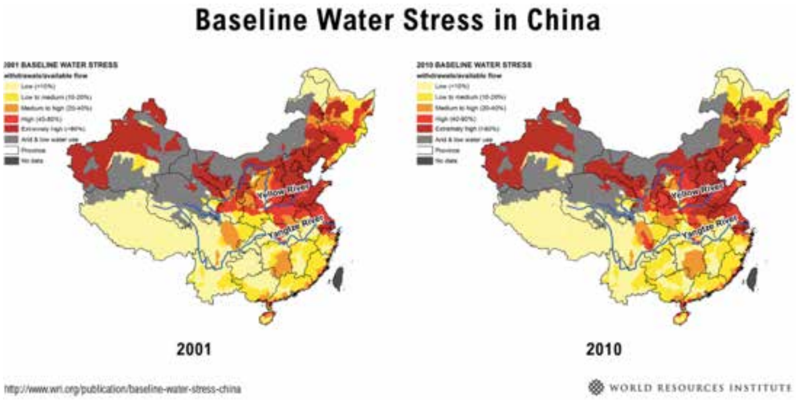
In 2007, as a follow-up to the research in former Soviet Central Asia, a research project started in Xinjiang (the Xinjiang Uyghur Autonomous Region (XUAR) to be precise). It was financed by the Royal Netherlands Academy of Arts and Sciences (KNAW), together with Nanjing Agricultural University (NJAU) and Xinjiang Agricultural University (XAU). One of my Chinese colleagues, Professor Shi Xiaoping, a PhD from ISS, was the counterpart. In late 2008, after lengthy negotiations and procedures, we undertook a farm survey in nine villages (three townships) in the southwestern county of Awati.

As the security situation was already slightly tense, XAU students of Uyghur descent (and mostly from these localities) conducted the interviews, in order to have a trusted entrée, and make the interviewees feel at ease. I participated only in what my Chinese colleagues called "waste visits", to comparable villages and farms which were afterwards not included in the sample. My presence as a foreigner would have attracted too much attention from the authorities and influence the farmers' responses in undesired ways. The research gave a fascinating insight into the livelihoods of small-scale cotton farmers struggling in a harsh ("saline") environment, and with ever smaller water quota.[5]

5 Water allocations to farms were reduced because of a new policy to direct more water towards the tail end of the Tarim basin to promote environmental recovery.

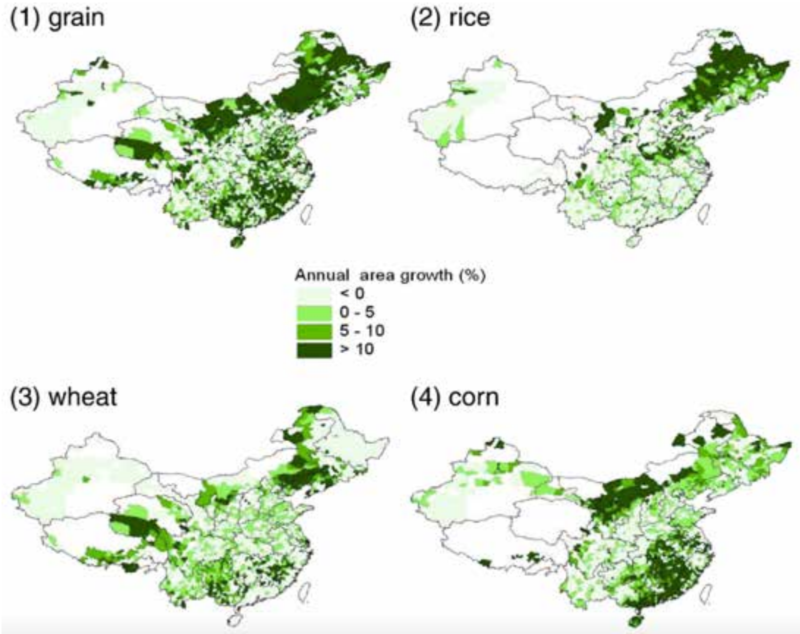
Unfortunately, in July 2009, there were violent and deadly clashes between Uyghur and Han-Chinese inhabitants of various cities in Xinjiang (in particular in the capital, Urumqi). This caused a complete shut-down (telephone, internet) of the region. We had to terminate the project, although our Chinese counterparts were still able to conduct a follow-up farm survey. We were, however, not allowed access to the data for publication, as it was considered too sensitive. One of the interesting outcomes of the original survey was that farmers found trust more important than formal land certificates, in particular in the use of wasteland. Tree planting, particularly on wasteland, was seen as a way to secure land tenure, contrary to mainstream economic theory arguing that secure land tenure is needed for investment to take place. In the Tarim basin, widespread cotton production has led to overuse of water, waterlogging, soil degradation, and finally salinization of soil, rivers, drainage canals and water aquafers. Although there is some awareness in policy circles of the need to divert water to the environment, i.e. the downstream areas, the pressure to keep producing cotton remains unchanged, or is being replaced by an expansion of wheat in marginal (wasteland) areas (see Rao et al., 2016).

As part of the Programme of Strategic Alliance of the KNAW, together with Nanjing Agricultural University and Tsinghua University in Beijing, led by Wageningen University (WUR), we were then involved in research in Gansu, part of the semi-arid belt of northern China, and elsewhere.




In the late 2000s, we saw experiments with the introduction of partial water markets for lease or user rights. These were often interfered with by the authorities, and the outcomes remain somewhat ambivalent (see Lei Zhang, 2013). Zhang et al. 2008 were more optimistic about local (particularly market-led) responses, and made an effort to distinguish water shortage problems at regional and district levels, as there is large variability. Water pricing is also being introduced, in particular at local levels, although this needs to be accompanied by enormous investments in metering systems, and enforcement by policy institutions and markets.

With co-authors from the International Food Policy Research Institute (IFPRI), we found for the period 1980-2003 substantial migration of grain crops, such as rice and wheat, from central-eastern and southern China towards the northeast of the country. In an article in the China Economic Review, we argued that the main cause of this lies in rapid urbanization, with rising land prices forcing agricultural production to migrate to the north (You et al. 2011).




This development makes sense in strictly economic terms. Through an ecological lens, however, it is disastrous. Production increasingly takes place in areas with relatively less water, leading to higher water stress. Water tables in northeast China, where well-driven irrigation is widespread, have drastically lowered, while in Xinjiang the situation is even worse (Spoor, Arsel, and Jiang, 2012). The water crisis in northwest, north and northeast China is already severe, and is expected to become more problematic in the near future. Li et at. (2016: 24) recently stated:

> The North of the country, holding nearly half of the total population of China and 65% of the arable land, has only 18% of the total water resource. In many areas, agricultural production is now highly dependent on groundwater, which together with more intensive use of water for industry and daily life has resulted in an unsustainable decline in the water table of around 40 cm each year.

For deep-water resources, this reduction seems to be even between 1 and 2 metres per annum. This more intensive use of groundwater resources, withdrawn from greater depths, is costly in terms of well construction, as well as in energy to get the water up to field level. In addition, climate change has caused temperatures to rise, with higher levels of evaporation aggravating water shortages, by increasing demand from agriculture. As Li et al. (2016) state:

> The average temperature has increased by 1.2 $^0$C since 1961 in China, precipitation has declined in the already dry North and more and variable rainfall is expected in the wet South.

The Chinese government has taken policy measures to promote water for the environment, as well as the introduction of water certificates and water markets (see Zhang et al. 2008). It has also embarked on a gigantic plan to connect the Yangtze, Yellow, Huaihe and Haihe rivers, to bring water from the wet south to the north. This South-to-North Water Diversion Project is to be completed by 2050.


GUARDIAN GRAPHIC

However, it is questionable whether this is the solution to the problem. It may only postpone the crisis and could have serious unexpected negative environmental consequences. If water has to be lifted to higher altitudes, as is mostly the case, the energy costs will be huge, and more fossil fuels will have to be used. Apart from these plans, the northeast of China and some of its largest cities, such as Beijing, are getting large quantities of "virtual" water. This happens through the import of primary agricultural products from abroad to feed the meat industry. The same occurs through transports from the southern provinces of rice and other agricultural products for human consumption (Zhang, Yang and Shi, 2017).

A complicating factor is that Central Asia and northwest China largely depend on water from melting glaciers for their freshwater resources (IPCC 2008: 87; cited in Spoor, Arsel and Jiang, 2012: 81):

> A projected increase in surface air temperature in north-western China is, by linear extrapolation of observed changes, expected to result in a 27% decline in glacier area, a 10-15% decline in frozen soil area, an increase in flood and debris flow, and more severe water shortages by 2050 compared with 1961-90.

Kraayenbrink et al. (2017), in a recent article in Nature, are even more pessimistic on the future of the Asian glaciers, estimating that with a 1.5 degree increase in temperature, an estimated 64 +/-7 per cent of "present day ice mass stored in high mountain area glaciers will remain". In less conservative temperature rise models, this could even lead to a maximum of 35 percent. This will have "serious consequences for regional water management and mountain communities" by the year 2100, for downstream agricultural areas.

These areas will be hit hardest by the impact of climate change on water availability. Water shortages in semi-arid areas might mean lower yields, or even complete harvest losses.  In tropical and moderate zones greater variability in rainfall will cause flooding and damage to harvests, as seen lately.

Industrial agricultural systems seem to have a lower total water footprint when taken as all water involved in domestic production, harvesting, processing, transport and marketing. Since these systems use concentrate based on grains imported from elsewhere, the blue water footprint (and the related water stress) is larger than under mixed grazing systems. Industrial systems of meat production also lean heavily on the outsourcing of cereal, soybean and cotton production to developing countries.

Enormous flows of water are thus embedded in agricultural produce through 'virtual water trade'. The effects are very real, (see Mekonnen and Hoekstra, 2011; see figure on 'virtual water imports into Europe'), and imply additional environmental costs by operating a fossil fuel-driven production, processing and transport system.


Legend: Virtual water imports into Europe. Source: Mekonnen, M.M. and Hoekstra, A.Y. (2011)

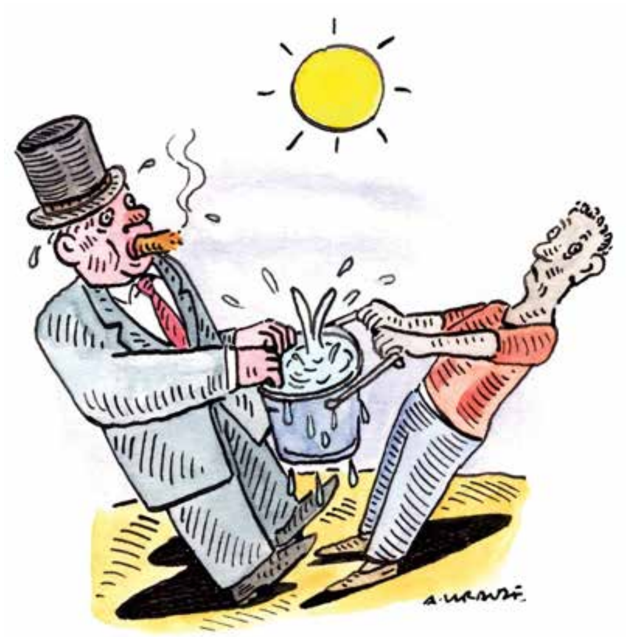
A global population of 9 billion people by 2050 will not only require more food to survive; with growing incomes, they will demand higher food quality and move from grains towards meat. We see this already in the current "meatification" of global food consumption, and an increasing global "hoofprint" (Weis, 2013). This phenomenon is visible in China, often seen as the guilty party in this process, but also in other countries where the middle classes are expanding and diets shifting.

A large proportion of global food is still produced by small farmers or peasants partly for home consumption, yet the corporate large-scale farming sector is expanding. This is visible in developed countries, but also in many developing countries and in Eastern Europe (see Spoor and Visser, 2011). Corporate capital has expanded its control over agricultural production through large-scale land acquisitions, land grabs which include eviction and loss of livelihoods.


Author drawing: Natalia Mamonova

Corporate control over global food chains has also meant increasing financialization, with the associated future markets, and speculation as was seen in the 2007-08 food price crisis. Furthermore, there is a shift in investment from food to fuel crops, depending on the market situation and price expectations (see Borras et al. 2016).

This is leading to a situation where small farming is mostly gradually, but in some places rapidly, being replaced by large-scale farming run by corporate capital. Much has been written about productivity differences between these two modes of production. We are still having tense debates about the "peasant way" and the seemingly natural path of capitalist farming in which peasant or small-scale farming is doomed to disappear (see Van der Ploeg, 2008 vs. Bernstein, 2010).



China has shown that peasant farming can be efficient and productive. The country, however, is now moving towards land concentration, partly under the pressure of increased migration and labour constraints in rural areas. Furthermore, it has incentivised peasants to introduce inter-cropping, particularly in the arid and semi-areas of the north and west, and introduced widespread reforestation (Rao et al., 2016). It is engaging in many experiments to introduce water certificates and even water markets at village level, in order to improve water-use, as mentioned before.

Even though small, multifunctional farms are environmentally more sustainable than large monoculture ones, there is not much research on the use of water in relation to farm size and the farming system. Initial evidence of large-scale food production or of industrial crops shows that water use is increasing. This may lead to the exhaustion of water aquafers, which are often shared with neighbouring communities. Blue water resources are more intensively used, in particular in large-scale irrigation schemes. Fast-growing tree varieties such as eucalyptus have become very popular, but deplete blue water resources and lead to soil degradation.

Soil salinization caused by over-exploitation of aquafers leads to upward mobility of minerals and hardening of top soils. This is a major global problem, which is intimately tied to water stress, especially in Central Eurasia. It is estimated that, by the year 2050, around 50 per cent of arable land in the world will be affected by salinity (FAO, 2009). A recent study by the UN Natural Resource Forum stated:

> Well-known examples of salt-induced land degradation include the Aral Sea Basin (Amu-Darya and Syr-Darya River Basins) in Central Asia, the Indo-Gangetic Basins in India, the Indus Basin in Pakistan, the Yellow River Basin in China, the Euphrates Basin in Syria and Iraq, the Murray-Darling Basin in Australia, and the San Joaquin Valley in the United States. The anthropogenic environmental changes resulting from salt-induced land degradation in the Aral Sea Basin are considered to be the largest in recent times (Qadir et. al, 2014).


Another hidden form of mineral pollution is caused by excessive use of chemical nutrients, in particular nitrates. A recent study by Ascott et al. (2017) published in Nature Communications found vast quantities of nitrate in underground layers (known as the vadose zone), just above groundwater level. The press release stated "as the stored nitrate is released from the rocks into rivers via springs, our precious ecosystems face the risk of a grim future of toxic algal blooms and fish deaths".

Finally, water stress is aggravated in many river basins around the world because of more intense conflicts between downstream and upstream countries and/or populations. These conflicts are about the use of water and also about the timing of water use. Downstream populations often need water in the crop-growing seasons; say, for the sake of simplicity, spring and summer. Water is needed upstream to generate electricity for heating in winter. It passes through the turbines, thus releasing it from the artificial lakes in front of the dam. It may then run down, when not needed for irrigation, and cause flooding in the cold deserts downstream. These problems can be seen in all large river basins in Central Eurasia, and can lead to conflict. They can only be solved through negotiation (Arsel and Spoor, 2009). Sometimes energy-water swaps can offer a solution, or the upstream country (or users) can be paid for letting water through the dams when it is needed downstream. However, such arrangements remain a potential cause of tension, as the livelihoods of millions of people depend on water. [6]

Let us now return to the starting point of this address, namely increased water stress in relation to climate change. We have already noted the emerging phenomenon of climate migration. Increasing numbers of these migrants need to be defined as "water-stress migrants", though we should not forget that there are many "push" and "pull" factors behind decisions by migrants to leave their homes (Van der Heijden et al. 2017; SIWI, 2016).

6 In a region in which nearly all countries are governed by authoritarian or semi-authoritarian regimes, negotiations become often much more complex.

The complex problem of water stress and its future development under climate change needs to be studied in a multidisciplinary manner, combining quantitative surveys with qualitative and ethnographic research.  This must be done in a radical, path-breaking way. Not only social scientists, including economists, sociologists and anthropologists should work together (by the way, these are all social scientists…, although some of my economist colleagues seem to disagree). Social and political scientists should work with experts from other sciences, including biology, meteorology, soil science, hydrology, hydrogeology, physics and chemistry, to study the complexity of this theme now and in the near future.

Coming myself from the science side (math, physics and astronomy) I have learned that this is unavoidable, and also fruitful. We need to see water and land as an integrated resource, as precious "environmental stock" (Spoor, 1998), which should be taken care of in a sustainable way. Let us not forget, that nobody, be it a small farmer or an absentee investor, will invest in land if water resources for agricultural production cannot be guaranteed.

We have to investigate potential solutions, such as community water management, collective action, payments for environmental services, water pricing, water markets, privatization of services, drip irrigation, plastic covers for seedlings, salt-resistant crops. We also need to dare look at completely different consumption and production patterns. The journey through Central Eurasia I have taken you on today, while focusing on "water, land and farmers", shows that water stress in semi-arid regions is one of the most important problems to be tackled in the near future. The region has lately received public attention, through the revival of the Silk Road, and the massive Chinese investments in the One Belt, One Road initiative. However, these investments in new transport facilities, dry ports and industrial zones might well ignore the problematic environmental state of affairs indicated above. Looking critically at problems of water stress, land degradation and the consequences for the millions of farmers and rural households needs to be on top of the research agenda.

In conclusion, only when we all put our minds to it and join forces, will we be able to understand global issues like water stress. Only then will we be able to formulate solutions, propose radical systemic changes, and pressure our politicians to implement them. All this is for the benefit of generations to come. One such systemic change should concern scientific research and education, which has become more and more disciplinary and often inward-looking. By contrast, our environmental problems, such as those related to water stress, have become more complex and interrelated.

Young researchers are incentivized to publish in the journals of their discipline or even sub-discipline, are punished in the current promotion criteria if they think "out of the box" and kept in a straightjacket through today's harsh "publish or perish" rules. Path-breaking multidisciplinary research is dis-incentivized, on the finance side as well as in terms of publication outlets.

In the end, this will be a self-defeating strategy if we, as scientists, do not help solve such complex problems. Actually, universities will need more space for manoeuvre, in fundamental, experimental and applied research, and in terms of new innovative and particularly multidisciplinary teaching and research programs, that will attract and train the type of future scientists that we really need.

## Acknowledgements:

Instead of thanking everybody who deserves credit, I would like to mention the organizations where or with which I have worked in the past decades. These are the University of Leiden, in particular the Central Calculation Institute, its Foreign Relations Bureau, Vlietschans Secondary School, the Science and Technology Committee for Vietnam, Laos and Cambodia, the Medical Committee Netherlands-Vietnam, the National Autonomous University of Nicaragua, Timiriasev Academy Moscow, Kazakh State Agrarian University, Diplomatic Academy Almaty, Tashkent Agrarian University, Clingendael Institute of International Relations, the Dutch Ministry of Development Cooperation (DGIS), Nuffic, UNDP, FAO, the Economic Development Institute of the World Bank, IFAD, CARE, CEBEMO, CORDAID, the KNAW China Committee, Wageningen University, ISSAS/ISS, CIDOB and IBEI in Barcelona and finally, for the past 27 years, the International Institute of Social Studies, part of Erasmus University Rotterdam since 2009. Here in particular I would like to thank my colleagues of our research group, the AFES Master's program and my PhD students, those who have already finished and those who still have the arduous task to do that. It was and still is a privilege to work with you. Thanks also to the colleagues who have always helped me and assisted me in organizing things, or saved me from harm.

Finally, a particular word of thanks to my parents, my brothers and sister, who long ago wondered whether I would ever settle down and find my way, and last but not least to my compañera Francisca, and our adult children Saskia and Friso, who have always been and are an inspiration for us.

Ik heb gezegd.

# Bibliography:


Arsel, M. and M. Spoor (2010), *Conflict and Cooperation: Water, Environmental Security and Sustainable Development in Central Eurasia,* London: Routledge.

Ascott, M.J., D.C. Gooddy, L. Wang, M.E. Stuart, M.A. Lewis, R.S. Ward & A.M. Binley (2017), 'Global Patterns of Nitrate Storage in the Vadose *Zone', Nature Communications, 1416.*

Bernstein, H. (2010), *Class Dynamics of Agrarian Change*, ICAS Agrarian Change and Peasant Studies Series, No. 1, Canada: Fernwood Publishing.

Borras, S.M., J.C. Franco, S. R. Isakson, L. Levidow and P. Vervest (2016), 'The rise of flex crops and commodities: implications for research', *The Journal of Peasant Studies*, 43 (1): 93-115.

FAO (2009), 'How to Feed the World in 2050: Technology Challenge', FAO High-level Expert Forum, Food and Agriculture Organization, Rome.

Heijden, K. van der, B. Otto & A. Maddocks (2017), 'Beyond Conflict, Water Stress Contributed to Europe's Migration Crisis', Blog, World Resources Institute, 3/11/2017; Available at www.wri.org; Accessed 10/11/2017.

IPCC (2008), 'Climate Change and Water', Technical Paper VI, Intergovernmental Panel on Climate Change, IPCC, WMO and UNEP, Geneva: Switzerland.

IPCC (2013), 'Climate Change 2013: The Physical Basis', *Assessment Report* No. 5, Chapter 13: Sea Level Change, Intergovernmental Panel on Climate Change, IPCC, WMO and UNEP, Geneva: Switzerland.

Kraayenbrink, P.D.A., M.F.P. Bierkens, and W.W. Immerzeel (2017), 'Impact of a global temperature rise of 1.5 degree Celsius in Asia's glaciers', *Nature* 549: 257-60 (September).

Li, X., N. Lou, L. You, X. He, H. Lou, M. Huang and S. A. Waddington (2016), 'Pattern of Cereal Yield Growth across China from 1980-2010 and their implication for Food Production and Food Security', *Plos One* 11 (7): e0159061, 1-37.

Mekonnen, N.M. and A.Y. Hoekstra (2011), 'National Water footprints accounts: the green, blue and grey water footprints of production and consumption'; *Value of Water Report Series*, No. 50, UNESCO-IHE, Delft.

Ploeg van der, J-D (2008), *The New peasantries: struggles for autonomy and sustainability in an era of Empire and Globalization*, London: Earthscan.

Qadir, M., E. Quillerou, V. Nangia, G. Murtaza, M, Singh, R.J. Thomas, P. Drechsel, and A.D. Noble (2014), 'Economics of salt induced land degradation and restoration', *Natural Resource Forum* (a UN Sustainable Development Journal), 38 (4): 282-95.

Rao, F., M. Spoor, X. Ma and X. Shi (2016), 'Crop-tree intercropping and land tenure (in)security in rural Xinjiang', *Land Use Policy*, 50: 102-114.

Ruess, P. (2015), 'Mapping of water stress indicators', CE394k *Term Paper*, University of Texas.

Sen, A. (1981), *Poverty and Famines: An Essay on Entitlement and Deprivation*, Oxford: Clarendon Press.

Schlosser, C.A., K. Strzepek, X. Gao, A. Gueneau, C. Fant, S. Paltsev, B. Rasheed, T. Smith-Greigo, E. Bland, H.D. Jacoby and J.M. Reilly (2014), *Report No. 254*, Joint Program on the Science and Policy of a Global Change, Cambridge, USA: MIT.

SIWI (2016), 'Water, migration and how they are interlinked', *Report No. 27*, Stockholm: Swedish International Water Institute.

Spoor, M. (1998), 'The Aral Sea Basin Crisis: Transition and Environment in Former Soviet Central Asia', *Development and Change*, 29 (3): 409-436.

Spoor, M. (2012), 'Agrarian reform and transition: what can we learn from "the East"?', *The Journal of Peasant Studies*, 39 (3-4): 845-872.

Spoor, M., P. Jiang, and M. Arsel (2012), 'Local climate change, water scarcity and institutional responses in Xinjiang, China', in M.A. Mohamed Salih (Ed.), *Local Climate Change and Society*, London: Routledge, pps. 74-89.

Visser, O. and M. Spoor (2011), 'Land grabbing in post-Soviet Eurasia: the world's largest agricultural land resources at stake', *The Journal of Peasant Studies*, 38 (2): 299-323.

Weis, A. (2013), *Ecological Hoofprint: The Global Burden of Industrial Livestock*, Zed Books.

You, L., M. Spoor, J. Ulimwengu and S. Zhang (2011), 'Land use change and environmental stress on wheat, rice and corn production in China', *China Economic Review*, 22 (4): 461-473.

Zhang, L. (2013), Water, food and Markets - Household-level effects of policies and institutional changes in irrigation management in northern China, *PhD Thesis* University of Wageningen, The Netherlands.

Zhang, Z., H. Yang and M. Shi (2017), 'Alleviating Water Security in the North China Plain: The Role of Virtual Water and Real Water Transfer', 50: 205-219.

International Institute of Social studies (ISS)
Erasmus University Rotterdam (EUR)
Kortenaerkade 12
2518 AX The Hague
www.iss.nl
www.iss.nl/en/research/research-groups/political-ecology