Biodiversity and Land Use in Central Asia

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Contents

1 INTRODUCTION

One of the overlooked aspects of the global environmental crises is the loss of biodiversity. According to the International Union for Conservation of Nature, one in four mammal species faces extinction. Also many varieties of plants, insects and other life forms face extinction. Why does this concern us? Besides having an intrinsic value as part of creation, biodiversity is the basis for a stable ecosystem which provides us with fundamental "ecosystem services": fresh air, water, new soil, recreation. For the survival of humanity these services are crucial and therefore biodiversity needs to be protected. Also biodiversity represents a huge pool of genetic capital which might become valuable in the future.

Central Asia is an area which is very rich in biodiversity: it is a source of many of our domestic plants; it contains many local species and has been selected as one of the globally important eco-region of the WWF (WWF 2006). But this special area is in danger of losing its natural treasures through deforestation, industrialization and population expansion. People in this area depend to a high degree on the local agriculture and are living in a difficult economic and political situation. Therefore not only biodiversity (the heritage for future generations) needs to be taken into account but also the welfare of the currently living people in the region.

This report evaluates a policy to preserve biodiversity in Central Asia while at the same time protecting agricultural production. It does this using an integrated world model called IFs (Hughes 2006) to simulate and assess the implications of this policy in Central Asia for the time period until 2050. Current trends are forecasted in a base line scenario (this is what most likely is going to happen if nothing will be changed) and this is compared to an alternative, new scenario. Working through this scenario should give responsible planners enough confidence to implement the new policy.

2 FRAMEWORK

2.1 THE FOCUS AREA

The area of interest is the geographical region of Central Asia, comprising Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan (see figure 1). It is situated at the heart of the Eurasian continent with a total of 3,882 thousand square kilometers and a population of over 53 million people. It is a completely land-locked area characterized by large grassland planes, steppes and deserts, high mountain ranges and many vast lakes. It is an area where most of the land suitable for agriculture is already in use. It contains fragile ecosystems and is confronted with major ecological problems: desertification, water scarcity, soil degradation and loss of biodiversity (United Nations Development Program 2003). Central Asia is an arid area where life was always dependent on water and which is suffering additionally through the gigantic mismanagement of the Soviet Union era. Since the disintegration of the Soviet Union all these countries have become independent and are going through a process of political and economical transformation and of creating new governance structures.

Figure 1: Political map of Central Asia

2.2 THE FOCUS QUESTIONS

The specific questions under consideration are:

- Which are the indicators and drivers for the ecological situation in Central Asia?
- Which of the driving factors have the biggest impact for improving the ecological situation?

- What is their implication on the area of agriculture?

Because biodiversity is hard to measure, the size of land devoted to nature (mainly forests) will be used as a measure of biodiversity. This is reasonable as to some degree the amount of available space and the number of species is correlated. However, once a species is lost, increasing the forest area will not bring it back.

The forecast period is from 2005 until 2050.

2.3 Methodology

This study makes use of the IFs model (Hughes 2006), a global system dynamics model comprising all countries of the world. It consists of a statistical history and of trend/modeling forecast capabilities for questions of economy, society and environment. The IFs model is strongest in economical and social questions and is somewhat limited in environmental modeling, but it is these other factors which bring the most pressure on the environment.

The most important factors for describing the environmental/agricultural situation in Central Asia are:

- Water availability
- Forest area
- Agricultural land
- GDP per capita

As a conceptual framework ecosystem services as defined in (Millennium Ecosystem Assessment 2003) will be used to describe the benefits human society derives from nature. The environmental indicators should be ideally taken from within the framework of the ecosystem services. Unfortunately IFs provides – outside of the carbon dioxide and global warming topic - only two environmental indicators: water use and forest land. Theoretically, they could stand for all the ecosystem services (both for use and over-use):

- Provisioning: water and timber
- Regulating: forests have a part in the local regulation of water and climate
- Supporting: production of oxygen, soil formation
- Cultural: spiritual and recreational value of forests and the biodiversity they contain

However, these two variables would need to be much more differentiated. For example there is a big difference in terms of biodiversity and of ecosystem services between a primal forest and a timber plantation. Also water use in itself is a rough measure because it says nothing about water quality before and after use, about local/seasonal availability etc. Drivers for ecological change can be both direct and indirect drivers as described in (Millennium Ecosystem Assessment 2003):

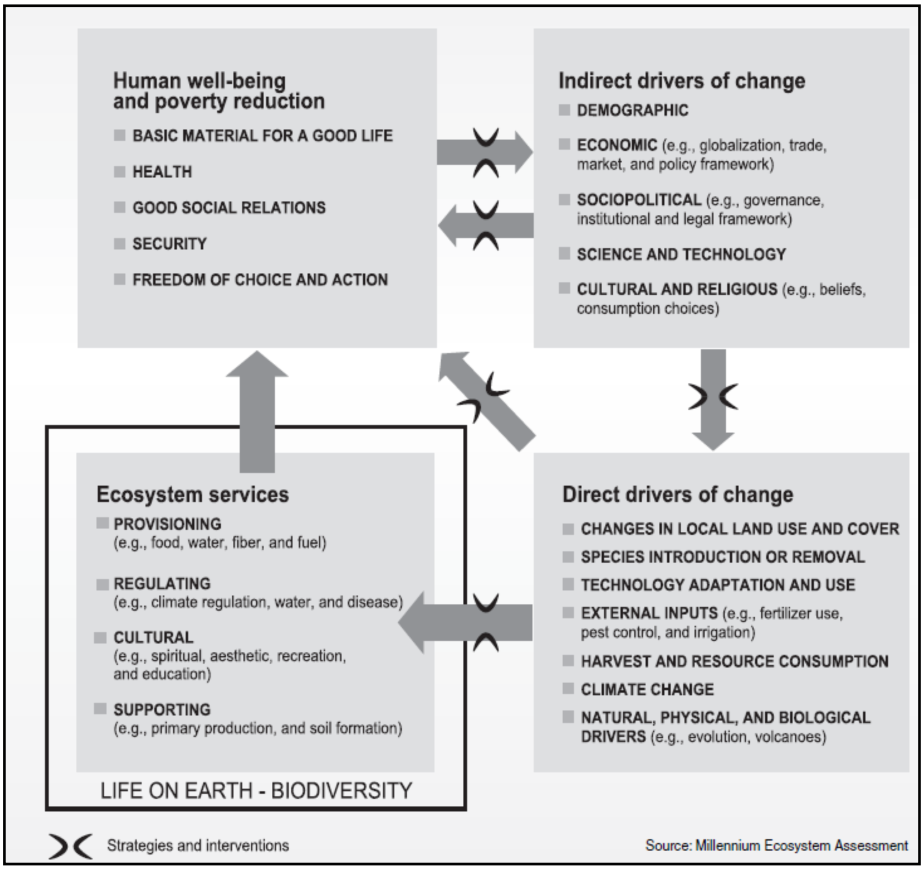


Figure 2: Framework of ecosystem services and drivers

Based on this, a general model of the causal influences and drivers for the environmental problems in Central Asia was developed (Kehl 2008):

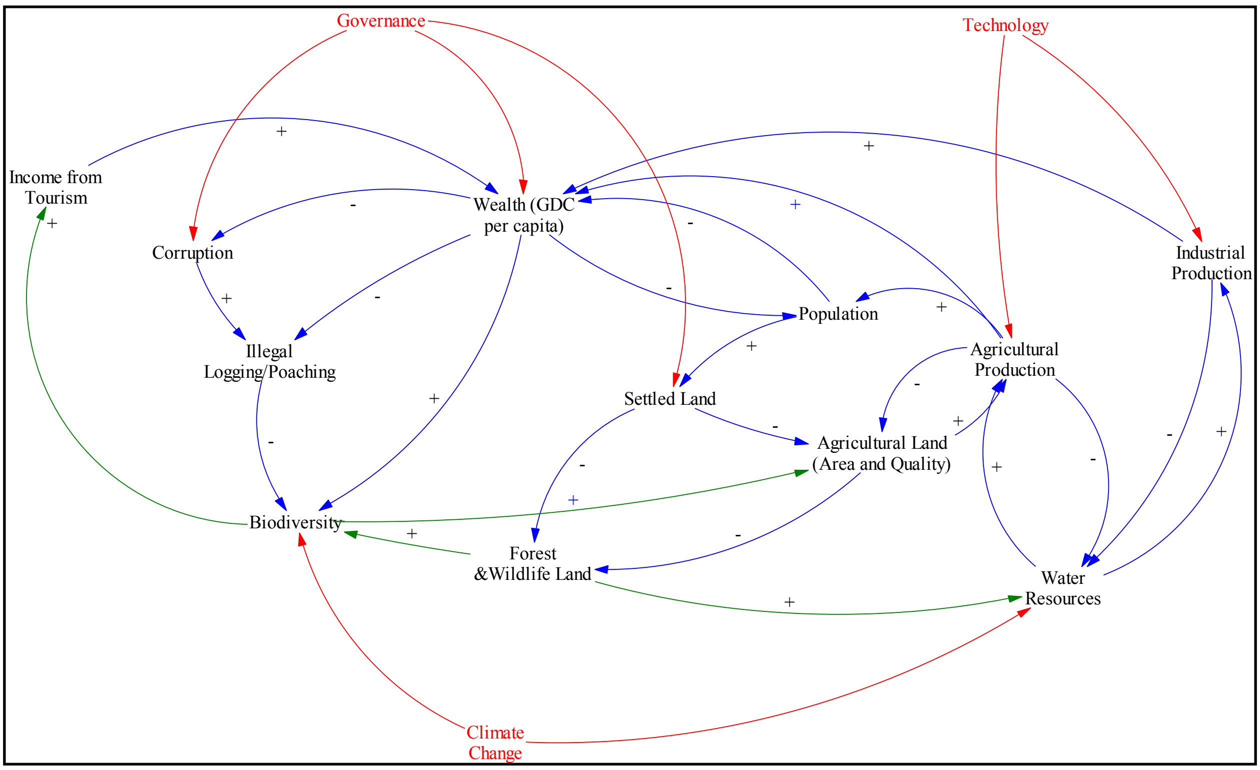


Figure 3: Causal Loop Diagram of Environmental Problems in Central Asia

Unfortunately, only a limited part of this model can be practically operationalized in IFs:

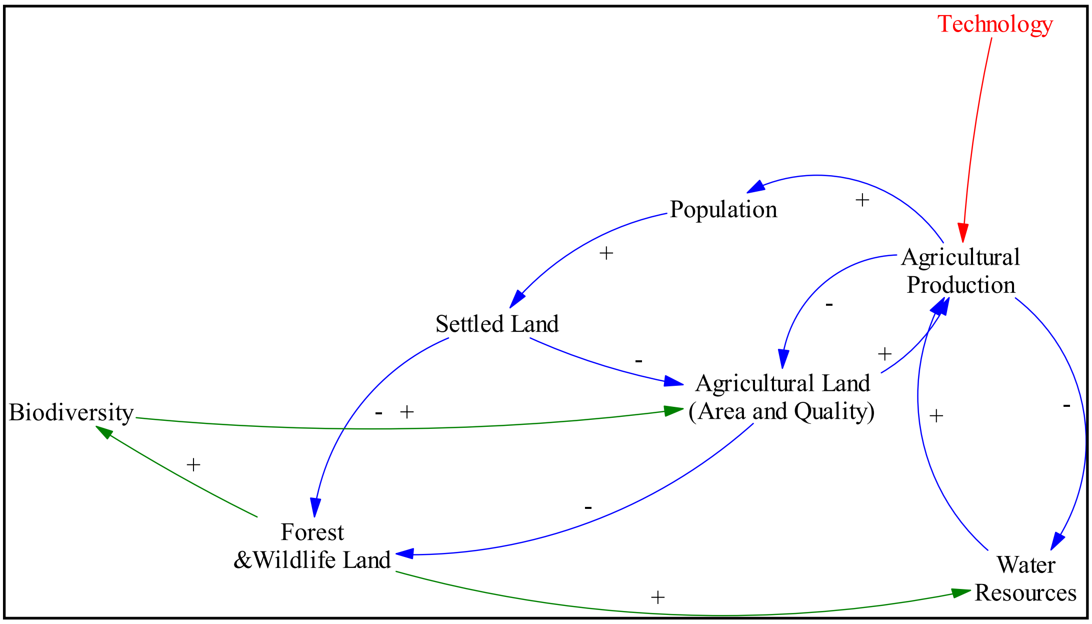


Figure 4: Causal Loop Diagram of Environmental Problems in Central Asia for use in IFs

Reducing the model in this way is a simplification and a limit to this study. However, what we can represent in IFs is done in a systematic way and can be backed up with statistical data. Apart from funding, is not possible to directly extend IFs with new variables. But even so, this study can build the basis for further modeling work and research.

3 THE BASE CASE

The purpose of the base case is to forecast the current trends of the most important indicator variables in IFs. It should not be taken as an absolute value (in the sense of a quantitative prediction), but as a reference for policy changes. Two of the most important indirect drivers of ecological change are population size and personal wealth. Figure 5 is showing that the population of Central Asia in the forecast period is still growing considerable, but the population size will stabilize around 2050.

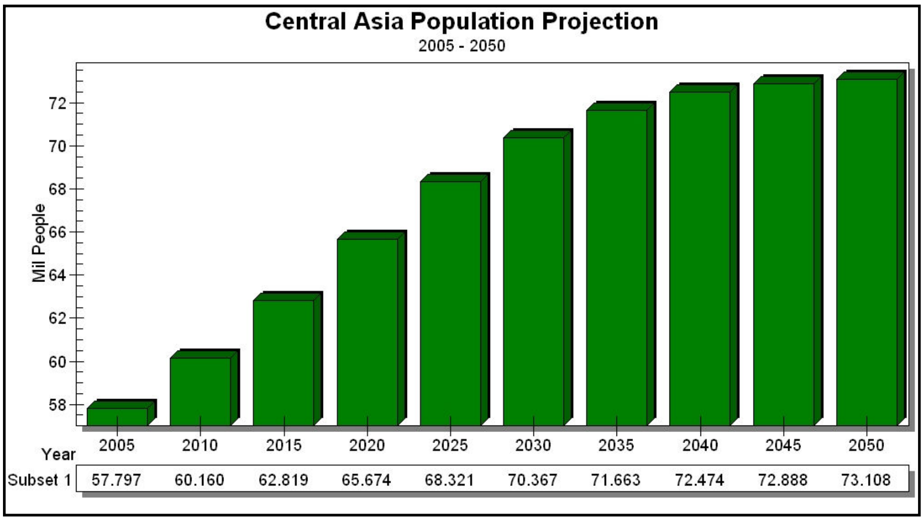


Figure 5: Population growth in Central Asia

A similar effect can be observed for individual wealth, which is expected to be continually increasing until 2050:

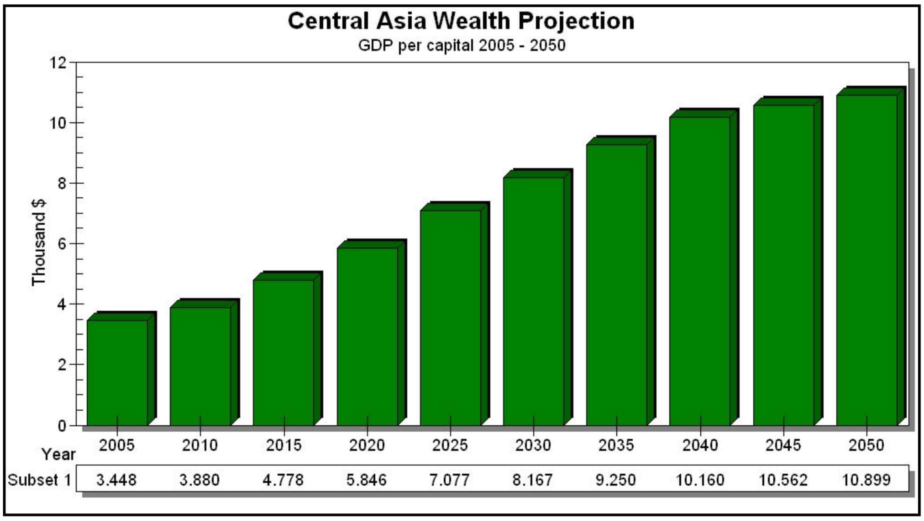


Figure 6: Growth of individual wealth in Central Asia

The environmental impact can be measured in IFs, as already mentioned above, mainly in two ways: in water use (WATUSE) and in forest land (LD – Forest).

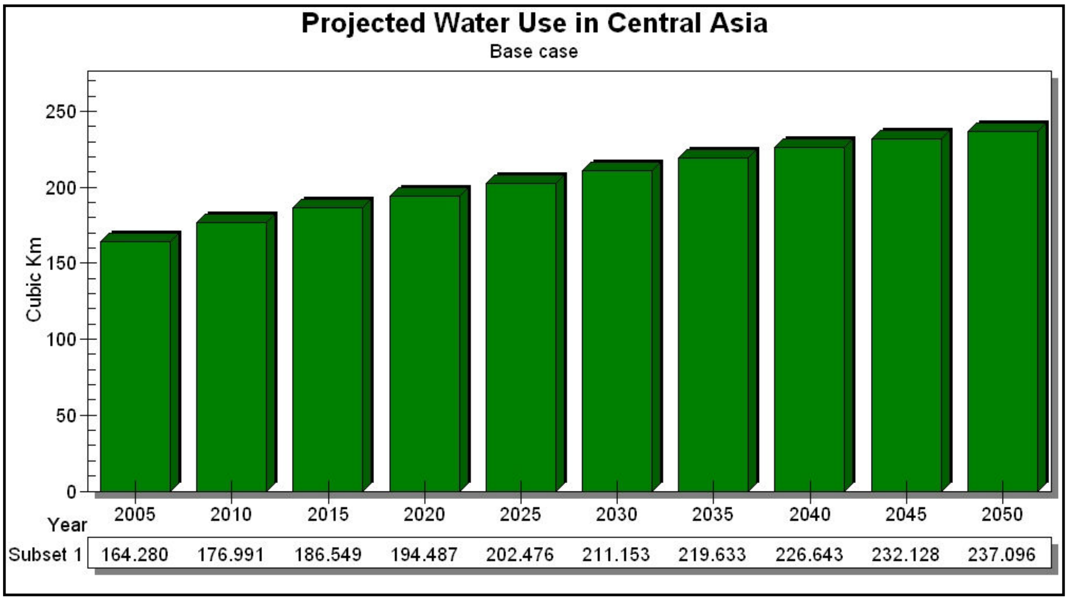


Figure 7: Growth of yearly water use in Central Asia

General water use is still expected to rise in Central Asia. Given renewable water resources of about 360 cubic km per year, it looks like there is no water problem. But the reality looks differently: water is a limiting factor everywhere in a region where the once huge Aral Sea is drying out and where water is a reason for conflict between neighboring Central Asian states. Therefore water use is a critical factor which has to be minimized.

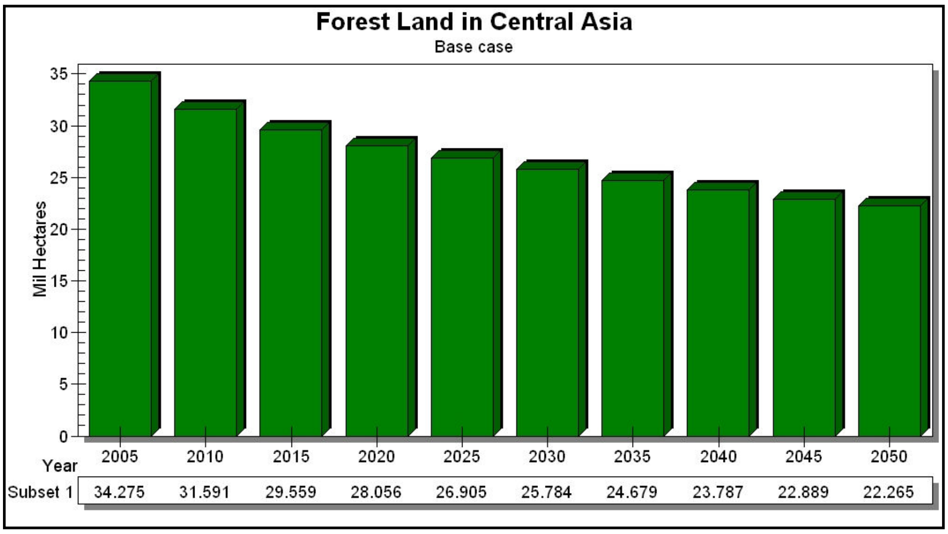


Figure 8: Reduction of Forest Land in Central Asia

Looking at figure 8, it becomes clear that biodiversity is under threat in Central Asia and with it many other ecosystem services. This is one of the main indicators of the underlying problem and the trend which must be turned around. It is expected that after 2050 the overall forest area will increase again. But already lost species cannot be recovered nor can the quality of the new forest expected to be the same as the original one.

As forest land is diminished, both crop and especially grazing land are growing. Accordingly, agricultural output is rising. However, the growth in figure 9 cannot be explained with available land alone, but also with increasing productivity through better technology and organization. An interesting fact in the model is that water availability is not a driving or limiting factor for agricultural production. This might be correct in the Northern hemisphere, but not in arid Central Asia where 70% of all water is used for irrigation and where irrigation was already used by the 7th century BCE. This important feedback loop would need to be closed to give the model more validity.

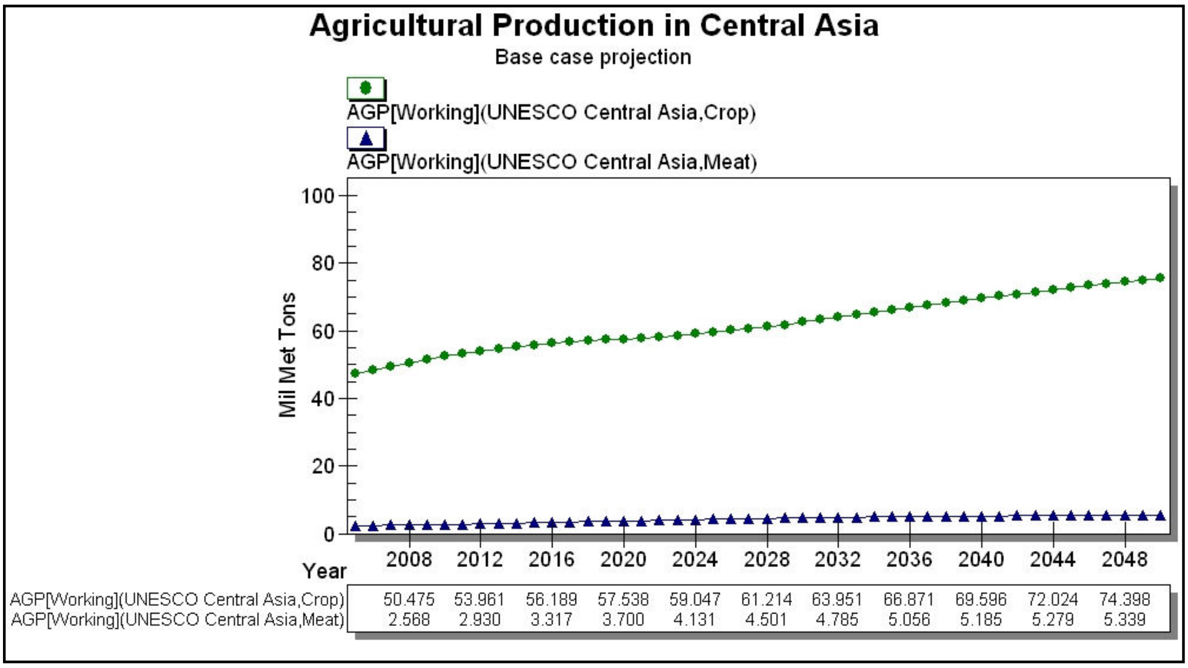


Figure 9: Reduction of Forest Land in Central Asia

In summary we can say that the future of Central Asia looks moderately positive with many indicators in IFs (this is also true for others which cannot be displayed here). However the indicators for the ecological system are showing a downward trend and give rise to concern for biodiversity and ecological services in the future. This is both motivation and background for developing a policy to improve the situation in this respect. How to formulate and evaluate such a policy with the help of IFs is the topic of the next chapter.

4 Policy Intervention

4.1 Drivers

From the causal loop diagram above (figure 3) a list of main and obvious drivers for the ecological situation in Central Asia can be identified:

- Population
- Land use (for agriculture, grazing, urban settlement, forests, other)
- Economic activities
- Governance

Of these, land use can both be influenced and is a direct driver for forest land (our proxy variable for biodiversity). There is no effect of a population decrease on land use. An experiment with decreasing the fertility rate even to an unrealistically low level shows no impact on land use. In general, ecological impact and population are correlated, but in the case of (undisturbed) forest land, there is probably no effect – even if the population levels off, land is not automatically given back to nature.

Also, neither economic activities nor governance are represented as direct change parameters for environmental indicators in IFs.

4.2 The Intervention

Given the limitations in drivers and causal links in the IFs model, there is only one realistic intervention possible: changing the "Forest Protection Multiplier" (forestm) which directly causes the area devoted to forest land to change (to increase for values > 1). This intervention represents a government regulation with the goal of increasing the available forest area and the biodiversity contained in it. In this intervention, because of the restricted environmental modeling in IFs, there is only a one-to-one linear relationship between the change of the *forestm* variable and the dependent *LD* land use variable. But this change has other, negative consequences, mainly on agriculture and nutrition. To balance these side effects, the intervention will be later extended in an iterative way.

The main intervention consists in a moderate change of the forest protection multiplier over a number of years. The goal is to increase the forest size by a factor of three over a 30 year period and then to stabilize it at that level. Experiments with different numbers and time periods have shown that there is no negative feedback loop in the model that limits the effect of increasing *forestm*. Therefore *forestm* can be increased only very moderately, otherwise the growth of forest land would displace all other kinds of land use. The change is a slow (interpolated) increase of forestm from 2005 until 2030 to a value of 1.1; immediately after that there is a return to the neutral parameter value of 1 (figure 10).

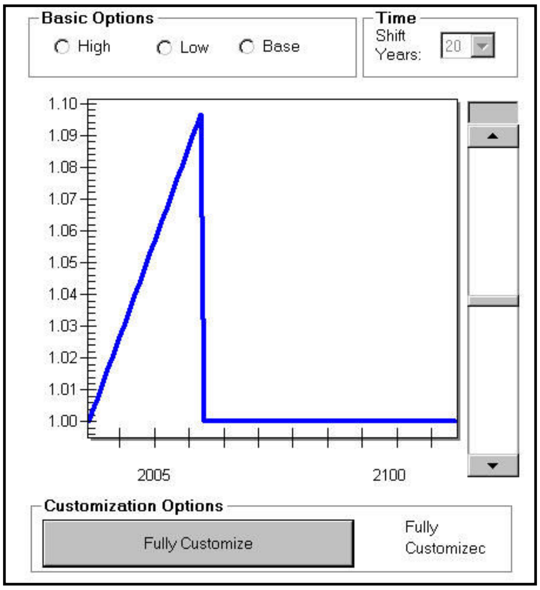


Figure 10: The forestm intervention

After running the scenario with these values, the main effect on the overall land use can be seen in figure 11:

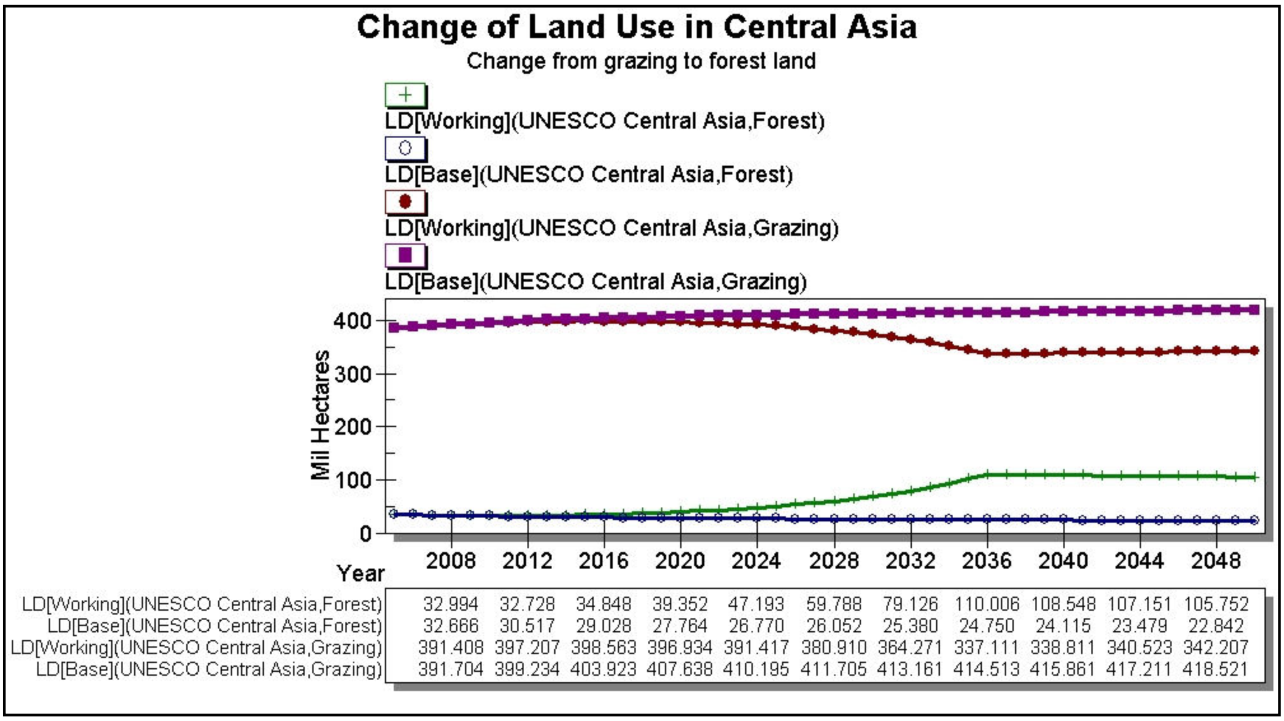


Figure 11: Change of Land Use in Central Asia

Here we can see in the working scenario a more than 300 percent increase of the forest area through this intervention. It is obvious that the bulk of this addition (49 of overall 73 mil hectares) comes from grazing land. The rest of the

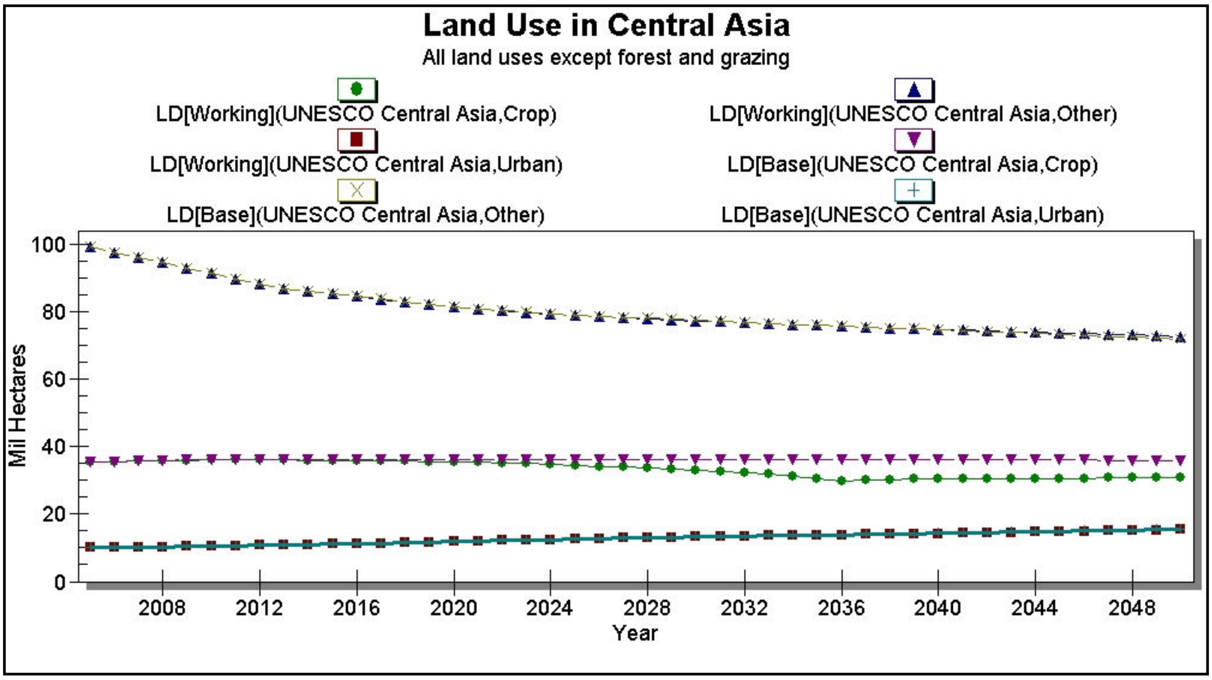
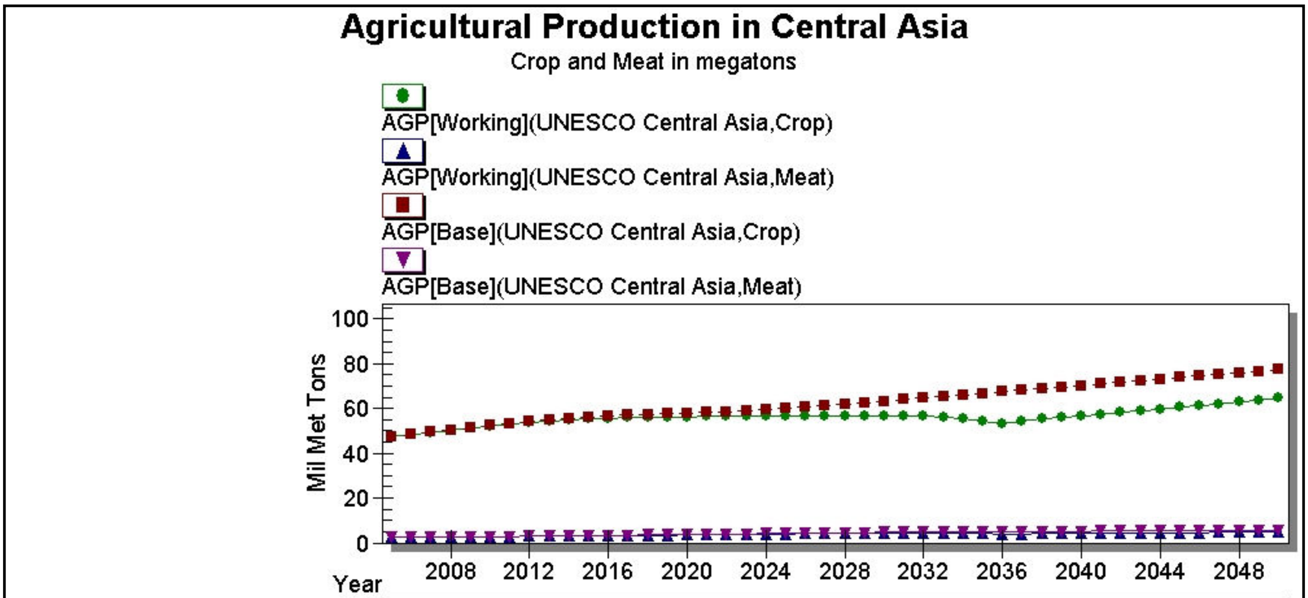


Figure 12: Scenario 1 versus base: Other types of Land Use in Central Asia

increase comes from crop land, as can be seen in figure 12. The difference in the crop land area does not seem to be very big, but it makes quite a difference in the agricultural effects of this intervention. The two other areas of land use (Urban and Other) are not affected by this intervention.

There is an immediate effect of the change in crop land on agricultural production, which can be seen in figure 13:



Year	2008	2012	2016	2020	2024	2028	2032	2036	2040	2044	2048
AGP[Working](UNESCO Central Asia,Crop)	50.437	53.722	55.752	56.350	56.664	56.604	56.433	53.226	56.569	59.697	62.968
AGP[Working](UNESCO Central Asia,Meat)	2.568	2.915	3.258	3.582	3.931	4.161	4.169	4.067	4.228	4.482	4.738
AGP[Base](UNESCO Central Asia,Crop)	50.502	54.106	56.600	57.971	59.540	61.700	64.733	67.512	70.252	73.101	75.906
AGP[Base](UNESCO Central Asia,Meat)	2.569	2.931	3.308	3.676	4.113	4.501	4.752	5.004	5.220	5.392	5.594

Figure 13: Scenario 1 versus base: Agricultural Production in Central Asia

Crop production is affected to quite some degree, so that the overall crop production after the intervention is significantly lower than in the base case. The change is directly correlated to the available crop land; one can see a similar pattern here as in the crop land curve above. Interestingly, the production of meat is not so heavily affected, although grazing land is reduced much more than crop land.

The change in agricultural production leads to negative consequences regarding the nutritional situation in Central Asia: agricultural imports are rising and (more alarming) the number of malnourished people is slightly bigger than in the base case (see figures 14 and 15). So it seems that the increased import of goods is not sufficient to make up for the loss of crop land.

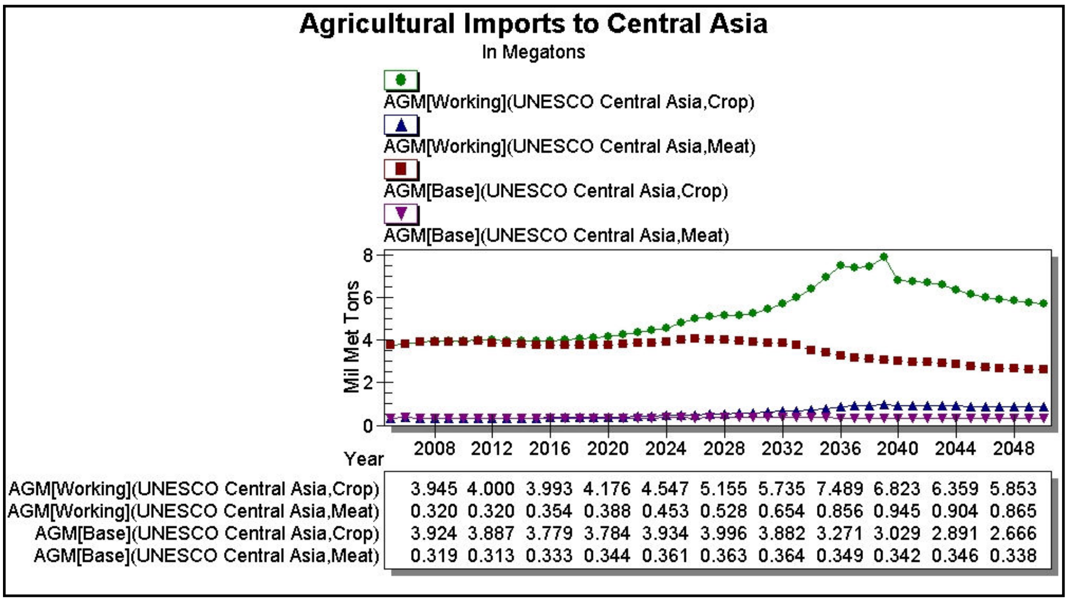


Figure 14: Scenario 1 versus base: Agricultural Imports to Central Asia

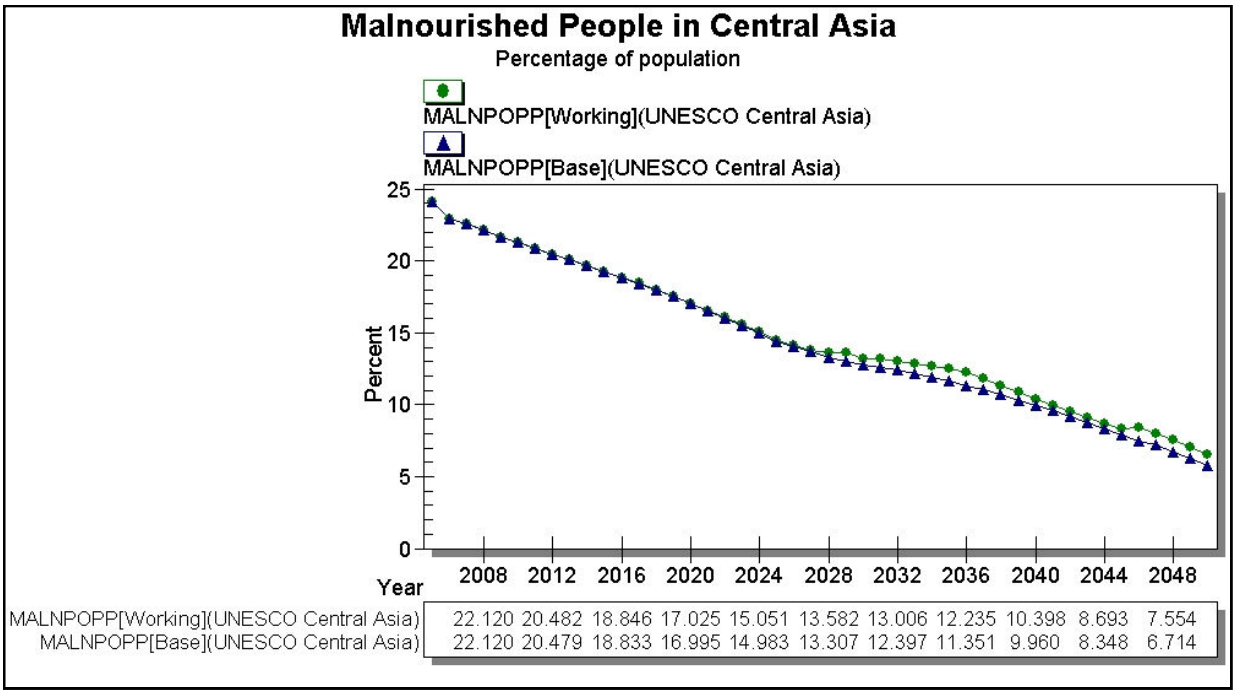


Figure 15: Scenario 1 versus base: Malnourished People in Central Asia

In terms of other consequences of the intervention, economic and social indicators seem to be completely unchanged – for example GDP per capita (*GDPPPC)* and the Human-Development Index (*HDI*) are not affected at all. In reality one would expect some changes, e.g. an effect of higher agricultural imports on GDP, but these effects are probably not significant. There is another ecological consequence of the intervention: the reduction of water use in the region, see figure 16. This is a direct result of the fact that about 70% of water is used for agricultural irrigation – if the agricultural area is reduced, so is the overall water use. Other positive effects of an increase forest area for the water situation (e.g. increase of overall water resources and water quality) could be expected but these kind of causal links are not represented in the IFs model.

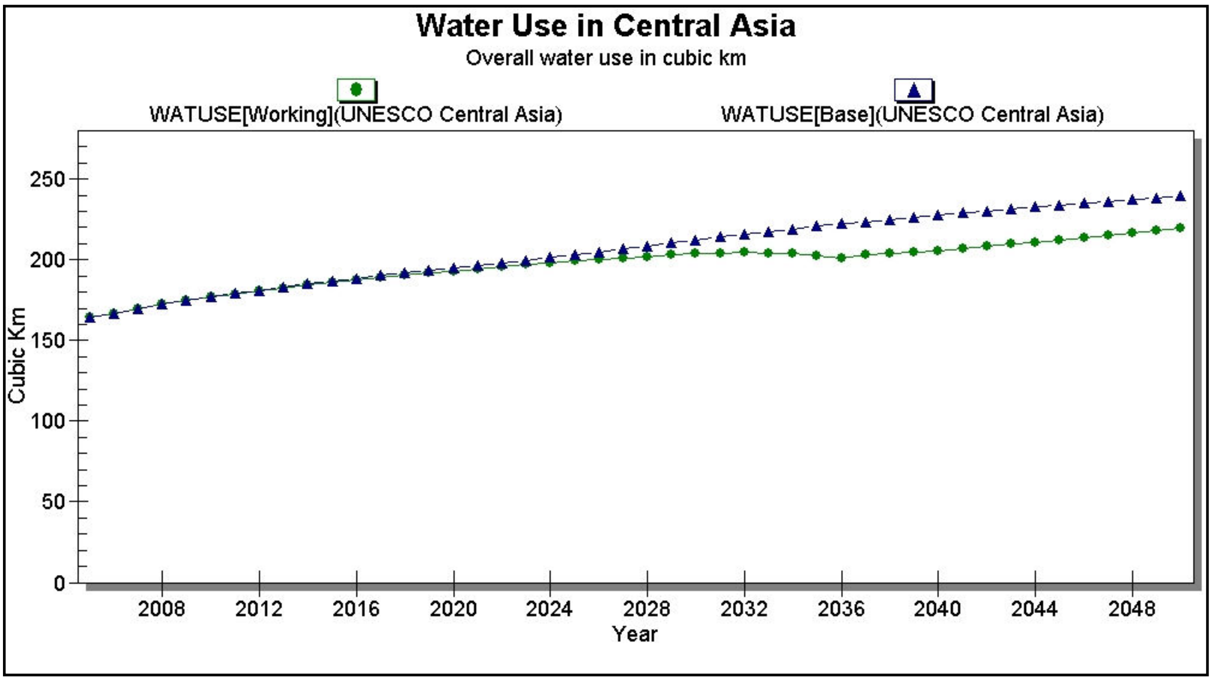


Figure 16: Scenario 1 versus base: Water Use in Central Asia

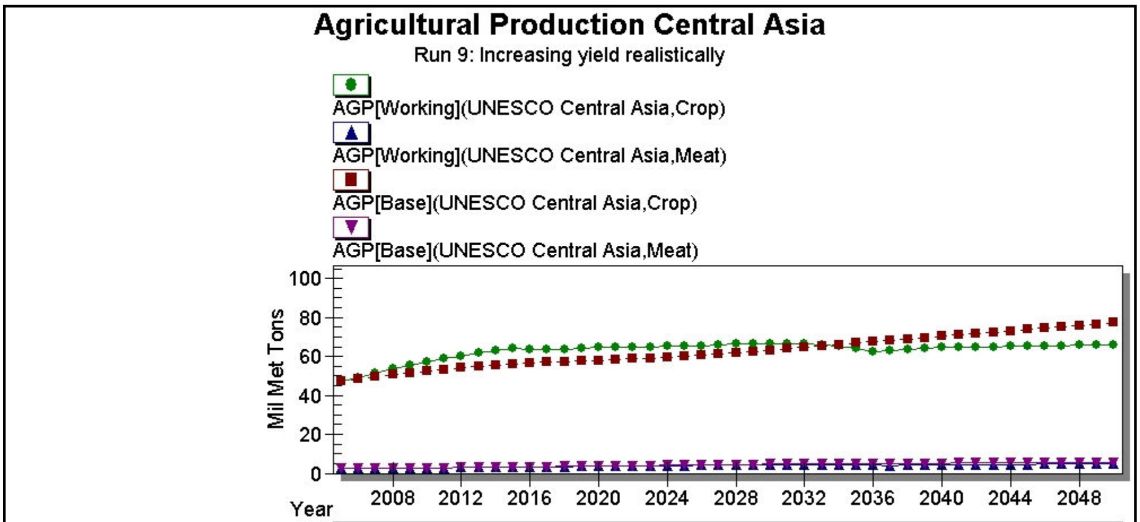
4.3 BALANCING THE INTERVENTION

The results of the intervention show an inherent conflict between improving the ecological versus improving the agricultural situation. Whereas this conflict cannot be completely eliminated, it is possible to modify the intervention to some degree to at least achieve a more balanced result. Various modifications have been tried out and added to the original intervention.

One possibility is to change the depreciation rate of agricultural land investment (*DKL*) to a lower level: following the same pattern as the original *forestm* change, *DKL* was linearly decreased from 0.01 to 0.005 until 2035 and then changed back to its original value of 0.01; *DKL* stands for land degradation and similar effects. It is fair to assume that with a bigger forest area the ecosystem services (e.g. better protection from erosion) can account for this change. However, it does not lead to any significant change in the crop land size. This indicates that in general the effect of soil degradation and soil loss, which is a huge environmental problem in Central Asia, is not properly reflected in the model.

Another candidate for influencing the size of land available for food production is to limit the growth of urban areas. This was done with the parameter *ldwf* (land withdrawal from agriculture with population growth). This parameter was changed to a “low” setting with the basic options in IFs scenario tree. But also this change to the scenario did not affect the crop land size at all – neither did it change urban land size.

With all parameters for increasing the available agricultural land exhausted, the only way to balance the intervention is to try and increase agricultural productivity via the agricultural yields multiplier (*ylm*): an additional change was introduced into the policy intervention to model a somehow realistic increase in agricultural productivity. The yield multiplier was increased over a period of 10 years to a value of 1.2, then kept at this level until 2035, at which time it was changed back to the neutral value of 1. This should model a high effort to increase yields, another effort to keep it at this level and a saturation effect. Still, improving the agricultural productivity by a factor of 1.2 per year is high and cannot be explained with technological progress alone. In an area which is dominated by export crops (e.g. cotton) this could also be achieved by changing away from production for export to production for domestic food needs. How this would affect the domestic economic situation and the supply situation in the importing countries cannot be investigated in this study. Another source of agricultural products could be the forests themselves which can be harvested to some degree without impacting their ecological stability. The result of this change is an increase in agricultural production which improves the situation but which still cannot fully make up for the decrease in agricultural land (see figure 17).



AGP[Working](UNESCO Central Asia,Crop)	53.420	60.353	63.702	64.469	65.307	66.267	66.403	62.101	64.445	65.077	65.628
AGP[Working](UNESCO Central Asia,Meat)	2.566	2.918	3.268	3.594	3.947	4.194	4.210	4.111	4.274	4.535	4.787
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AGP[Base](UNESCO Central Asia,Meat)	2.569	2.931	3.308	3.676	4.113	4.501	4.752	5.004	5.220	5.392	5.594

Figure 17: Scenario 2 versus base: Agricultural Production in Central Asia

On that basis, the percentage of malnourished people in the population is reduced compared to the original intervention, but it is still higher than in the base case (see figure 8). Also the average number of calories per capita per day (*CLPC*) is still lower than in the base line scenario.

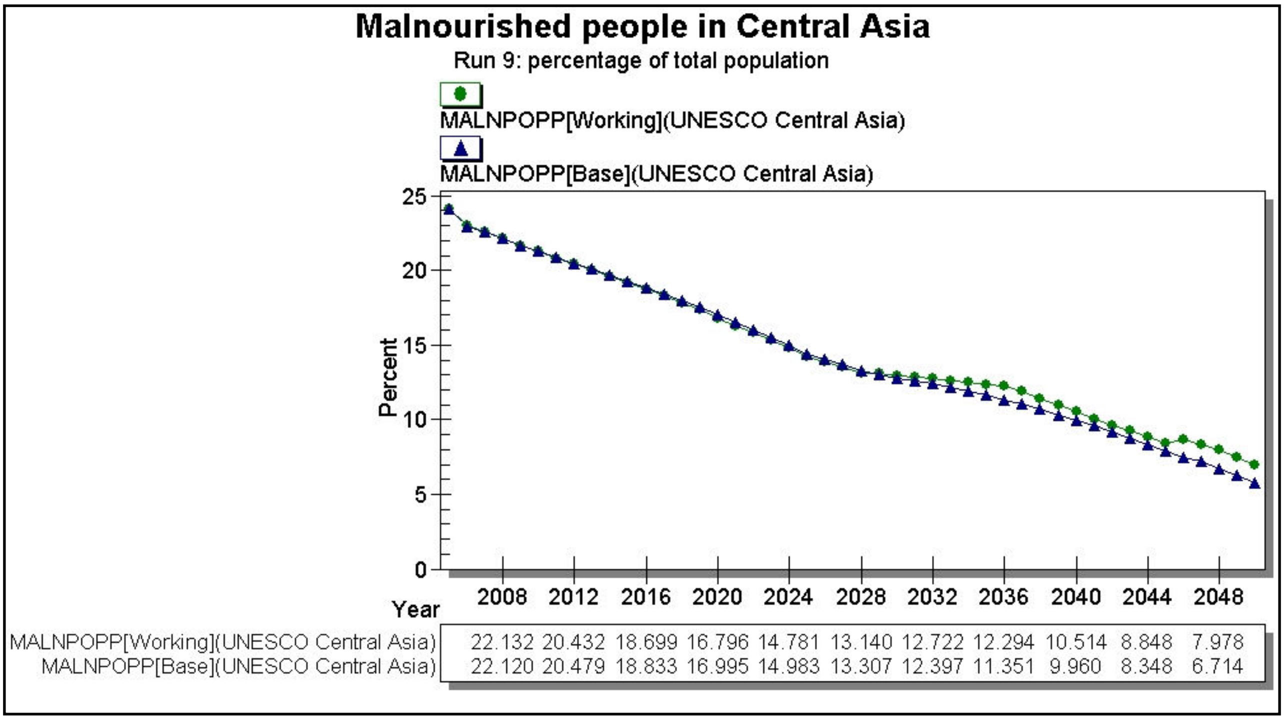

Figure 18: Scenario 2 versus base: Malnourished share of population in Central Asia

The only measure which is left to improve the situation even more is to reduce the projected population by a policy which decreases the fertility rate (*tfrm* – total fertility rate multiplier). Setting *tfrm* to a "low" value in IFs leads (all other factors staying the same) to a situation where the average calories intake by 2050 will be only 35 calories lower than in the base case and where the share of malnourished people by 2050 is reduced to 7.73% - slightly less than the 7.978% without population reduction. In this way we have reached a situation where the original goal of improving forest area and preserving biodiversity has been reached and where the negative consequences of reduced agricultural production have been limited as much as possible.

Although not present in the model, in reality there are more causal relationships between forest area and economic factors (forest products, possible income through tourism) and between social factors and biodiversity (it needs good governance to set up, protect and properly manage forest areas). Also in the timeframe up to 2050 there most certainly will be effects of global warming on both forest and farming land. These effects have not been studied here because they are currently too uncertain to model. They could go in many different ways (reducing crop land in quality and quantity, making more higher-altitude land available for farming, reducing available water for irrigation …) that they would introduce too much speculation into this scenario work.

As a summary, the best policy to address the underlying issue in a balanced way is to protect and increase the forest area, to improve agricultural productivity by a variety of means and to try to reduce fertility in order to reduce population pressure on agricultural products.

5 CONCLUSION

This study has shown three important results:

- the planned intervention is possible and can be done together with additional measures in a relatively balanced way,
- there still is a conflict between different goals which cannot always be solved
- Our modeling approach is helpful but still very far from accurately reflecting the complexities of real life.

The goal of the study is to simulate and plan a policy which would create a change in Central Asia towards preserving biodiversity and keeping a stable basis for ecological services to the population of this region. Given its limitations, is has shown that such an approach can work and that the negative side effects of such a policy can be contained with flanking measures. It has also shown which policy parameters have a significant influence and which can be neglected. In this way this study also gives some hints which measures should be undertaken first. The whole study has been done in an iterative process of policy development, which is only possible within the framework of such a modeling and planning exercise – in reality the measures take such a long time to show effects that it is usually too late to react when problem symptoms are detected.

The study also shows that following one goal has consequences on other, conflicting goals. In our case the conflicting goals are obviously the preserving of biodiversity and agricultural production. The suggested policy contains many measures to balance the adverse effects of increasing forest land as much as possible. But even in the model it was not possible to completely harmonize both goals and it is not to be expected that this will be possible in reality. That means that in the end people still have to decide which goal they prefer and this decision must be based on their values. Even a helpful planning tool like this leaves the final responsibility to the people who have to decide, to their priorities and their images of the future.

This study has also shown the limitations of the underlying model. For all of its virtues as an integrated world model, ecological questions and causal feedback loops are not well accounted for in IFs. The model basically assumes in its production functions – like most of the economic theory it is based on – that economic activity happens independent of ecosystems services. Also the causal links between the relevant parts of the ecosystem (water resources, soil quality, native and introduced species, etc) are not present in the model – which is not so surprising given that environmental data/statistics are complex and harder to integrate than economical data and that the interactions between them are not always well understood. Another limitation is the missing differentiation on a local level. For example the "forest area" does not differentiate between natural forests and tree plantations, and processes like desertification (expressed as changes in soil quality) cannot be modeled in the system. Therefore a much more detailed model for a limited area like Central Asia would be very helpful in order to get more reliable answers. But even then it must be clear that such a model can never fully represent reality and that using a model does not excuse from monitoring reality and taking responsibility.

Given all that, using (and further improving) a model like IFs is an important planning and decision-making tool because it gives our planning a statistical and systematic basis and because it leads our attention to the multiple and interrelated consequences of any policy. On this note we are positive that the suggested policy has the desired effect and will work for the long-term benefit of people and nature.

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The photos were taken by the author in the mountains of Kyrgyzstan.

7 About the Author

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