

Interactive comment on “Establishment and maintenance of regulating ecosystem services in a dryland area of Central Asia: the Kökyar Protection Forest, Aksu, NW China, as an example” by S. Missall et al.

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A) General comment

(no responses required)

B) Specific comments

Comment 01: “I propose a brief separate chapter/subchapter on the historicity of the project. It cannot be understood without referring to the national campaign / project of the Three North Shelterbelts. Shelterbelts provided by regular tree plantations have

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proven their usefulness under the conditions of 250 – 400 mm of annual rainfall, where they may survive with some auxiliary irrigation. But tree shelterbelts under totally arid conditions are a different matter, relying fully on irrigation. Thus one may ask: Did the national (political) macro-climate in favour for shelterbelts eventually prevent the examination of other more sustainable options to reduce the impact of dusty and sandy storms on the urban fabric? Also the switch to the forest leasing system has its national context as it was gradually introduced nation-wide since 1986.”

Response: First part of the comment adopted. A subchapter on the historicity of shelterbelts in China, including the Three North Shelterbelt, has been added. Second part of the comment not adopted. The question of the national political macro-climate is out of the scope of this paper, as is the question of other potentially more sustainable policy options. In response to the comment and in order to prevent further misunderstandings of the scope, we clarified the focus of our paper – which actually is on institutional frameworks and financial conditions of the protection forest – by formulating a clear research question at the end of chapter “1. Introduction”. Third part of the comment adopted. The national context of the forest leasing system is outlined at the beginning of chapter “4.1 The leasing system”.

Changes in the manuscript: First part of the comment – citation from chapter “1.1 Shelterbelts in China”: “More than 40% of China’s total territory is characterised by arid and semi-arid climates. These drylands are predominantly located in the north and especially in the northwest of the country (Li et al., 2012). Shelterbelts have been seen as an effective instrument to fight negative influences from deserts and semi-deserts ever since the beginning of the People’s Republic of China (Chokkalingam et al., 2006). The objectives of shelterbelts usually comprise environmental security (alleviating soil erosion, droughts, dust and sand storms, dry hot winds etc.) and economic development (increasing crop production, stockbreeding production, timber production and other forest products etc.). Structures and species compositions of the plantations alter according to site-specific conditions and purposes (Li et al., 2012, Chokkalingam et

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al., 2006). The biggest and globally best-known shelterbelt, the so-called Three-North Shelterbelt, is an overarching project that aims at increasing forest cover from 5% to 15% in an area of 4 069 000 km² that stretches over 13 province level administrative units all from the northwest to the northeast. Its establishment began in 1987 and is expected to last until 2050. 244 690 km² have been afforested so far (Li et al., 2012). A special shelterbelt type has developed in the Tarim Basin in northwest China. The Tarim Basin is framed by the Tian Shan Mountains in the north and the Kunlun and Karakorum Mountains in the south and southwest, the Taklamakan Desert lying in the middle. Continental position, precipitation shadow of the mountain ranges, and intense solar radiation form a hyper-arid climate. Oasis cities are located along the periphery of Taklamakan Desert, wherever rivers, running down from the surrounding mountains, provide sufficient water (cf. Fig. 1). Most of these cities, such as Korla, Būgūr, Aksu, Kashgar or Hotan, have experienced a rapid growth over the last decades, in the course of which natural greenbelts formed by native tree and shrub species have been eliminated by urban sprawl and agriculture. In order to protect the citizens from the influences of the surrounding desert lands, authorities of all these cities try to establish a special type of shelterbelt which could be labeled as peri-urban protection forest: broad greenbelts that optimally should surround the cities from all sides (Halik, 2003). The Kökyar Protection Forest in Aksu was one of the first of these.” Second part of the comment – citation from chapter “1.3 The Kökyar Protection Forest” (research question): “This paper undertakes an exemplary analysis of the Kökyar Protection Forest under the following research question: Under which institutional frameworks and to which financial conditions can peri-urban shelterbelts be established and maintained?” Third part of the comment – citation from chapter “4.1 The leasing system”: “In 1981, the State Council of the PR China had started promoting private forestry on a leasing basis by its “Resolution on Issues Concerning Forest Protection and Development” (guanyu baohu senlin, fazhan linye ruogan wenti de jue ding; for backgrounds cf. Delang and Yuan, 2015). In 1987, when the Kökyar afforestation work was still in the early stages, the Forest Management Station and Water Management Station reacted

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to this resolution and to the dire financial situation of their afforestation project, with the introduction of a leasing system that is fundamentally still in force today [...].”

Comment 02: I also propose another separate chapter/subchapter on the definition of the meteorological event of dust and as well as on the specific local climatic, topographic, pedologic and hydrologic site conditions including earlier human impacts (overgrazing etc.).

Response: Comment adopted. A section of the introduction, describing the geographic conditions of Aksu City, has been enlarged by the required information and upgraded to a separate subchapter (chapter “1.2 The geographic conditions of Aksu City”). Furthermore, chapter “3. The establishment of Kökyar Protection Forest” has been enlarged by a subchapter which describes the topographic, pedologic and hydrologic details of the Kökyar afforestation site (chapter “3.1 Site conditions”). Regarding earlier human impacts, we could not find information about the actual situation in Aksu, but we included general information about the usual human impacts around fast-growing oasis cities in the Tarim Basin.

Changes in the manuscript: Citation from chapter “1.2 The geographic conditions of Aksu City”: “Aksu is a city of about 580 000 inhabitants of which 314 500 live in the urban core (Akesu Shi Renmin Zhengfu, 2012). It is the capital of Aksu Prefecture, lying in the west of China’s northwestern Xinjiang Uyghur Autonomous Region, close to the border of Kyrgyzstan. At a geographical position of 41°10’ north and 80°15’ east and at an altitude of 1100 m above sea level, it is situated on a long, slightly inclined slope between the Tian Shan Mountains in the north and the Taklimakan Desert in the south (cf. Fig. 1). The slope is traversed from northwest to southeast by the Aksu River, which is fed by snow and glacier melt water as well as rainfall from the nearby Tian Shan Mountains as introduced in Rumbaur et al. (submitted to this issue). The Aksu River formed a flat 10 km wide river valley with a steep cut bank of about 20 m height at its northeastern shore. The core of Aksu City lies exactly under the cut bank within the river valley, while today’s suburbs spread deeper into the valley and on the bank. An annual

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evaporation rate of 1868 mm and annual precipitation of merely 75 mm indicate an extremely arid climate (Kökyar Annals Compilation Committee, 2006). Due to its location at the Aksu River, Aksu receives sufficient water to ensure agriculture, which places the city in a huge river oasis (ca. 1000 km², including Awat and Onsu County; Halik, 2003). However, the arid environment becomes very tangible whenever the regular hot and dry north winds blow down from the Tian Shan Mountains (Föhn effect). Maximum wind speeds are reached in springtime with 15 m s⁻¹ (Yoshino, 1992). Raising dust and sand from the barren areas north of the oasis, the north winds cause an annual average of 11.5 sand storm days (visibility less than 1 km) in Aksu City (Kökyar Annals Compilation Committee, 1996; also cf. chapter 3.2 Site conditions). The severe dust and sand storms of Aksu are blackening the sky, making respiration difficult, covering everything outside and inside houses with brown dust, inhibiting traffic, and disrupting public life (Aksu Prefectural Forestry Department and Kuqa Television Station, 2006; Aksu Prefectural Greening Committee, 2006; Aksu citizen interviews 2011).” Citation from chapter “3.2 Site conditions”: “The plantation site of the Kökyar Protection Forest lies in the north of Aksu City. It is a long stretch with an area of 1308 ha that extends 15.8 km from the Great Revolution Canal in the north to the suburbs of Aksu City in the south (cf. Fig. 2). It lies above Aksu City on an old fluvial terrace which slightly slopes from 1230 m above sea level in the north to 1125 m above sea level in the south. Most of its western boundary is defined by a steep cut bank of 20 m down to the Aksu River valley. The cut bank was canyoned by erosion gullies which extended deep into the area of later Kökyar, thus posing great problems for the levelling of the planting ground and construction of canals (Kökyar Annals Compilation Committee, 1996). The fluvial terrace itself is composed of brown desert soil lying upon a gravel bed. The grain size at the surface changes from sandy gravel in the north to sandy silt and clay in the south. A high groundwater table and the regional extreme evaporation rate result in an average soil salinity of 2.87% and pH-values of 7.1 to 9.0. Before the afforestation, the soil was predominantly devoid of vegetation, with some areas being sparsely covered by Alhagi spec. and other herbaceous plants. The barren soil of the Kökyar plateau was

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regarded as a major source of wind erosion, thus contributing to the regular northerly dust and sand storms in Aksu City (cf. Fig. 2; Kökyar Annals Compilation Committee, 1996; Aksu Prefectural Forestry Department and Kuqa Television Station, 2006).” Citation from chapter “1.2 Geographical conditions of Aksu City” (human impacts): “[...] the immigration-based growth and the economic development of oasis cities in the Tarim Basin usually was accompanied by degradation of the natural vegetation at the fringes of the oases, thus compromising their regulating ecosystem services and contributing to a factual aggravation of dust and sand problems (Halik, 2003). However, there is no literature on the specific situation around Aksu City.”

Comment 03: “The last paragraph of the text should be enlarged into a separate “Water” chapter discussing the water price issue (urbanites profiting from an almost non-existent agricultural water price). The authors mention the unbalanced distribution of water between upstream and down stream water users. This ethnic dimension of this imbalance – Han Chinese urbanites and farmers in Aksu versus Uighur farmers downstream – should also be mentioned.

Response: Comment partially adopted. The question of the true costs of water is indeed highly interesting and relevant, yet, this very big topic is beyond the scope of this paper and should be treated in a separate paper. But in response to this comment, we clarified the focus of our paper – which actually is on institutional frameworks and financial conditions of the protection forest – by formulating a clear research question at the end of chapter “1. Introduction”. Furthermore, in chapter “4.3 The perspective of the farmers”, we made more explicit that the water prices stated in our paper do not reflect externalities, but rather reflect the costs of the irrigation infrastructure and its operation. Finally, we extended the section on externalities of water consumption in chapter “5. Discussion and outlook” and integrated the ethnic dimension of this conflict there.

Changes in the manuscript: For citation of the research question cf. to comment 02, second part of the comment. Citation from chapter “4.3 The perspective of the farm-

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ers”: “Irrigation water fees usually fall between 1125 CNY ha⁻¹ and 1275 CNY ha⁻¹. (These prices probably represent the costs of the irrigation infrastructure and operation; they do not reflect externalities.)” Citation from chapter “5. Discussion and outlook”: “[...] the negative consequences of the Kōkyar water consumption for downstream ecosystems need to be investigated. Principally, every drop of water diverted from Aksu River for the purpose of irrigating the Kōkyar Protection Forest is detracted from its lower reaches and its main stem, the Tarim River. The improvement of the quality of life of Han-Chinese settlers in Aksu is thus bought by the resulting desiccation of downstream ecosystems and the consequent loss of downstream ecosystem services, which deprives local Uyghur farmers and herdsman of their livelihoods. Internalising these downstream effects into the Kōkyar water prices may challenge the net-benefit and the positive image of Kōkyar Protection Forest.”

Comment 04: “Technical terms should also be given (in footnotes or in an annex) in Chinese. For instance “compulsory labour” in contrast to “forced labour”.”

Response: Comment adopted. The Chinese technical terms have been added in italic letters in brackets directly after their English translations. The chosen transliteration is Hanyu Pinyin. We have chosen to translate the Chinese term “yiwu laodong” as “compulsory labour” instead of “forced labour”, since “forced labour”, in the English context, rather is something that happens in penal camps. This type of labour would be referred to by a different Chinese word.

Changes in the manuscript: For important technical terms, Chinese transliterations in Hanyu Pinyin have been added in italic letters in brackets directly after their English translations throughout the text. In order not to overburden this reply to the referee, just one exemplary citation from chapter “3.5 Compulsory labour” is given: “In order to meet the challenge of establishing huge forest areas in a poor financial situation, a legal regulation adopted in 1981 obliging all Chinese citizens to participate in “National Compulsory Afforestation Campaigns” (quanmin yiwu zhishu yundong) played a key role (Halik, 2003; interview 1). Based on this regulation, beginning from 1986 the

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Aksu Prefectural Party Committee called “all citizens, no matter which ethnicity, military or civilian” to participate in compulsory labour (yiwu laodong) on the fields, levelling the terrain, preparing the ground and planting trees with hard physical labour Kōkyar Annals Compilation Committee, 1996; interview 1).”

C) Minor comments/questions and technical corrections

Comment 05: “1675 On the one hand, the abstract is rather detailed and deserves some shortening, on the other hand it does not pose any guiding question. Would this be the question:? To which extent is it possible to identify costs and benefits of an erosion control project within the given political and administrative framework of a remote Chinese city?”

Response: Comment adopted. The abstract has been shortened and the guiding question has been integrated.

Changes in the manuscript: Citation from “Abstract”: “The city of Aksu, situated at the northern fringe of the Taklimakan Desert in northwest China, is exposed to periodic severe dust and sand storms. In 1986, local authorities decided to establish a peri-urban shelterbelt plantation, the so-called Kōkyar Protection Forest, with the aim to reduce dust and sand storm impacts on Aksu City by the regulating ecosystem services provided by the plantation. It was realised as a patchwork of poplar shelterbelts and orchards. The total area of the plantation reached 3800 ha in 2005. The Kōkyar Protection Forest is exemplarily analysed to answer the following question: Under which institutional frameworks and to which financial conditions can peri-urban shelterbelts be established and maintained? The endeavour of planting the shelterbelt was made possible by the annual mass mobilisation of Aksu citizens, based on the Chinese regulation of the “National Compulsory Afforestation Campaigns”. Establishment costs amounted to ca. 60 000 CNY ha⁻¹ (ca. 10 000 USD ha⁻¹). Permanent maintenance of the plantation is facilitated by leasing orchard plots to private fruit farmers. From the perspective of the local economy, annual farming net benefits generated by Kōkyar fruit

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farmers more than compensate annual government grants for maintenance, resulting in an overall monetary net benefit of at least 10 500 CNY ha⁻¹ (ca. 1600 USD ha⁻¹) on the long-term average. For a more complete understanding of Kökyar Protection Forest, future research should be directed towards quantifying the effect of its regulating ecosystem services, and on investigating the negative downstream consequences of its water consumption.”

Comment 06: “9 – 11: The abstract contains the apodictic statement: “The regulating ecosystem 10 services provided by Kökyar Protection Forest clearly reduce dust and sand storm impacts on Aksu City”. But neither here nor in the actual article do the authors present any empirical evidence. Thus it remains an open question, whether the claimed ecological services of the shelterbelt system are really provided.”

Response: Comment partially adopted. The focus of our paper is on the institutional frameworks and economic conditions of Kökyar Protection Forest, and not on quantifying its ecosystem services. Nevertheless we must contradict this comment. We cannot find that this statement is apodictic. It is a hypothesis that can be verified and falsified by evidences. Since we have two evidences in favour of the statement (cf. chapter “4.2 The perspective of Aksu citizens”) and none against it, for the time being we assume it to be true. In response to this comment and in response to further comments by our referee Johannes Kuchler (compare below), we rephrased the section containing the evidences in chapter “4.2 The perspective of Aksu citizens” in order to make the state of knowledge and the basis of the information more explicit. Furthermore we reinforced the argument of Kökyar providing regulating ecosystem services by a more detailed description of the nearby dust field that has been closed by the Kökyar Protection Forest, including its soil composition, position in reference to Aksu City, and main wind direction in the chapters “1.2 Geographic conditions of Aksu City” and “3.2 Site conditions”. Finally, since the queried statement appears to be provocative, and since in the abstract we do not want to put emphasis on a point that actually is not in the focus of the thesis, the statement has been replaced by a less controversial formulation.

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Changes in the manuscript: Citation from chapter “4.2 The perspective of Aksu citizens”: “An improvement of the dust and sand storm situation of Aksu City after the establishment of Kökyar Protection Forest is claimed by the Kökyar Annals (Kökyar Annals Compilation Committee, 1996; for details cf. next paragraph) and has been perceived and described by Kökyar farmers (socio-economic household survey 2012) and Aksu citizens (Aksu citizens interviews 2011; also cf. Halik, 2003).” For citations from chapter “1.2 Geographic conditions of Aksu City” and “3.2 Site conditions” (regarding dust field and main wind direction) cf. to comment 02. Citation from “Abstract”: “In 1986, local authorities decided to establish a peri-urban shelterbelt plantation, the so-called Kökyar Protection Forest, with the aim to reduce dust and sand storm impacts on Aksu City by the regulating ecosystem services provided by the plantation.”

Comment 07: 23 The population figure of 570.000 refers to the total area of Aksu shi with more than 14.000 km². What is the population of Aksu’s actual urban core area to be protected by the Kökyar project?

Response: Comment adopted. Answer: 314,500. The number has been integrated into the text.

Changes in the manuscript: Citation from chapter “1.2 Geographic conditions of Aksu City”: “Aksu is a city of about 580 000 inhabitants of which 314 500 live in the urban core (Akesu Shi Renmin Zhengfu, 2012).”

Comment 08: “1676 21 – 24 The introduction does not establish any link to the national Sanbei Fanghulin scheme.”

Response: Comment adopted. A link has been established in chapter “1.1 Shelterbelts in China”.

Changes in the manuscript: For citation from chapter “1.1 Shelterbelts in China” cf. to comment 01.

Comment 09: “1-3: The topographic information is too general. The local topography

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of the urban area is of greatest relevance for the degree of impact of the annual dust and sand storms (see first lines of 1679)”

Response: Comment adopted. The topography of the urban area and the afforestation site has been described in more detail in chapters “1.2 The geographic conditions of Aksu City” and “3.2 Site conditions”.

Changes in the manuscript: For citations from chapter “1.2 Geographic conditions of Aksu City” and “3.2 Site conditions” cf. to comment 02.

Comment 10: 10: What is the official definition of a “sand storm event”? in 1685, 26, you speak of wind-born sand events. 20: Here you speak of dust storms. Is there any difference between a dust storm and a sand storm?

Response: Comment adopted. The expression “sand storm event” is an alternative translation for “wind-born sand event” (fengshaci). It had remained in the text by accident. The whole section containing this expression has been rephrased and based on other data. The expression “wind-borne sand event” (fengshaci) is used throughout the Kökyar Annals. It seems to be an outdated expression in the scientific context, similar to the English word “sand storm”. Yet, since there is no data in modern scientific language, e.g. in TSP (total suspended particles) from before 1996, we have to operate with this expression. The reader is informed about the complications of the expression in the corresponding chapter (“4.2 The perspective of Aksu citizens”). “Dust and sand storms” (shachenbao) is a collective term for dust storms and sand storms. Dust storms and sand storms are principally distinguished by particle sizes, but in the Chinese terminology, usually the collective term is used. We have no information on the particle sizes of the storms in Aksu City, but since the northern surroundings contain both clay and sand, a combination of dust and sand is the most probable.

Changes in the manuscript: Citation from chapter “1.2 Geographic conditions of Aksu City”: “[...] the arid environment becomes very tangible whenever the regular hot and dry north winds blow down from the Tian Shan Mountains (Föhn effect). Maximum

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wind speeds are reached in springtime with 15 m s⁻¹ (Yoshino, 1992). Raising dust and sand from the barren areas north of the oasis, the north winds cause an annual average of 11.5 sand storm days (visibility less than 1 km) in Aksu City (Kökyar Annals Compilation Committee, 1996; also cf. chapter 3.2 Site conditions).

Comment 11: “1677 12: “Hindukush–Himalaya–Tianshan region” What kind of region should this be? Dust and Sand Storms are primarily a meteorological event of the plains, not of high mountain areas.”

Response: Comment adopted: This formulation was based on an international workshop held 2013 in Hamburg (“Climate Change and Environmental Pressure: Adaptation and Resilience of Local Communities in the Hindu-Kush-Himalaya (HKH)”), where the combination of mountains and plains in Hindukush, Himalaya and Tian Shan were seen as challenged by similar problems. Since we see that it looks strange without this context, it has been deleted.

Changes in the manuscript: Citation from chapter “1.3 The Kökyar Protection Forest”: “It is a showcase project in China and could be a model for other drylands. [...] This analysis can turn out to be helpful for the planning or running of other similar projects, especially in geographically similar areas.”

Comment 12: “13: “systematically examine the establishment process”: This bold claim raises high expectations. Again, as in the abstract: the introduction does not arrive at a research question.”

Response: Comment adopted. The formulation has been replaced by an explicit research question.

Changes in the manuscript: Citation from chapter “1.3 The Kökyar Protection Forest” (research question). “This paper undertakes an exemplary analysis of the Kökyar Protection Forest under the following research question: Under which institutional frameworks and to which financial conditions can peri-urban shelterbelts be established and

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maintained?”

Comment 13: “18: data are drawn”

Response: Comment not adopted. To our best knowledge and to that of our native proofreader (New Zealand), “is” is fine here.

Changes in the manuscript: None.

Comment 14: “19: survey on Kökyar farmers? Should it not be of ??”

Response: Comment not adopted. To our best knowledge and to that of our native proofreader (New Zealand), “on” is fine here.

Changes in the manuscript: None.

Comment 15: “18-20: Since the objective of the study is not well identified, the information on methodology is “hanging in the air”. Why interview farmers, why not meteorologists, medical doctors, old cadres?”

Response: Comment adopted. The objective of the study has been clarified by the formulation of an explicit research question. In consequence, the information on methodology is no longer “hanging in the air”.

Changes in the manuscript: For citation from chapter “1.3 The Kökyar Protection Forest (research question) cf. to comment 12.

Comment 16: “21: What’s the meaning of “sound literature”?”

Response: Comment adopted. The word “sound” has been deleted.

Changes in the manuscript: Citation from chapter “2. Methods”: “Literature on Kökyar is scarce and until today available exclusively in Chinese.”

Comment 17: “1678 23: There is a national context for the Kökyar project: the 3 North shelterbelt system”

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Response: Comment adopted. The national context has been incorporated into chapter “1. Introduction” as subchapter “1.1 Shelterbelts in China”.

Changes in the manuscript: For citation of chapter “1.1 Shelterbelts in China” cf. to comment 01.

Comment 18: “1679 3: “Saline desert plateau” Such words suggest potential problems of salinization. Did they occur? They also suggest especially large quantities of irrigation water in order to “wash” the land to make it suitable for tree planting. But there is no mentioning of drainage facilities and drainage costs.

Response: Comment adopted. Drainage canals have been added in the list of infrastructure items (chapter “3.3 Design”) and in the list of tasks of the River Management Department (chapter “3.4 Key actors”). Furthermore, the salination problem has been explained in more detail in chapter “3.2 Site conditions”. The drainage canals were simple earth ditches of a total length of 14.5 km which drained the southern parts of Kökyar I by the natural slope of the area. Being a small and rather cheap detail of the overall infrastructure, its costs are subsumed in Table 2 under the costs of water engineering. Explaining these (and other) technical details in the text would overload the paper.

Changes in the manuscript: Citation from chapter “3.3 Design”: “Furthermore, the area is equipped with all necessary technical infrastructure, such as water gates, waterlocks, overflows, bridges, drainage canals, water tabs, power lines, telephone lines and administrative buildings.” Citation from chapter “3.4 Key actors”: “The main task of the River Management Department and its local Water Management Station lay in preparing the planting ground through spatial planning, bulldozing the terrain, establishing a road network, building irrigation canals and other hydraulic engineering for provision of irrigation water, and drainage canals to depress the saline ground water level (Kökyar Annals Compilation Committee, 1996; interview 1) [...]” For citation from chapter “3.2 Site conditions” cf. to comment 02.

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Comment 19: “2-6 The question of site selection remains nebulous: Please include a graph showing major wind directions and velocities (should be combined with fig 2) and give some information on the nature and quantity . of “sand” and suspended dust. How reliable were the meteorological data? What about soils as a source for wind erosion and being exposed to salinization?”

Response: Comment adopted. The question of site selection has been clarified by insertion of chapter “1.2 The geographic conditions of Aksu City” and chapter “3.2 Site conditions”. Main wind direction and velocities have been added to the text in chapter “1.2 The geographic conditions of Aksu City”. The main wind direction has also been incorporated into Figure 2. We do not have information on nature and quantity of suspended dust and sand of the past, but since the northern surroundings contain both clay and sand (cf. chapter “3.2 Site conditions”), a combination of dust and sand is the most probable. We have no specific information about the reliability of the meteorological data. Of course, soils are a source for wind erosion, and they are exposed to salination.

Changes in the manuscript: For citations from chapter “1.2 The geographic conditions of Aksu City” and chapter “3.2 Site conditions” cf. to comment 02. The changed Figure 2 will be uploaded separately.

Comment 20: “2: the relevance of local topography for the potential impact of the project is hidden behind the information, that the project was established on “a 20 m high saline desert plateau”. If I am not mistaken “high” here means 20 m high above the level of the Aksu River flood plain.”

Response: Comment adopted. The relevance of the local topography and its influence for the impact of the project have been further clarified by adding the chapters “1.2 Geographic conditions of Aksu City” and “3.2 Site conditions”.

Changes in the manuscript: For citations from chapter “1.2 The geographic conditions of Aksu City” and chapter “3.2 Site conditions” cf. to comment 02.

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Comment 21: “4: the plots of 0,5 – 1 ha exclude or include poplar plantations??”

Response: Comment adopted. They may include poplar shelterbelts in single or double rows at the edges of the plots, but they do not include the 100 m wide shelterbelts at the main axis of the area.

Changes in the manuscript: Citation from chapter “4.1 The leasing system”: “Leasing contracts guarantee them, for a period of about 10 to 15 years, a small section of orchard land (mostly between 0.5 and 1 ha, which may include single or double row poplar shelterbelts on one or two edges of the plots), regular irrigation water supply and some technical advice in fruit production (socio-economic household survey 2012).”

Comment 22: “11-12: the terms “ecological forest” and “economic forest” were introduced with the PRC forestry law (1984) please explain in foot note as many readers may not be familiar with this context.”

Response: Comment not adopted. The terms “ecological forest” and “economic forest” are easily misinterpreted, do not fit the categories of Kökyar Protection Forest well, and are not vital for the paper. Instead of explaining them in footnotes, we therefore preferred to omit them.

Changes in the manuscript: Citation from chapter “3.3 Design”: “The plantation was established as a raster of shelterbelt strips consisting mainly of white poplar (*Populus alba* ‘Pyramidalis’) with fruit plantations between. In the five years between 1986 and 1990, 686 ha of poplar shelterbelts and 623 ha of orchards were planted, totalling 1308 ha and 1 085 000 trees (Kökyar Annals Compilation Committee, 1996).

Comment 23: “25 Am I interpreting you correctly?: The new land-use-system is indeed a pure forestry system, (not agro-forestry, not silvo-pastoral) excluding cover crops (grain, fodder plants) and cattle breeding (sheep)???? Was water shortage the reason for omitting animals?”

Response: Comment adopted. The land-use system is not a pure forestry system, as

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is explained in chapter “4.3 The perspective of the farmers”. To avoid further misunderstandings, we inserted a link to this chapter in the queried section.

Changes in the manuscript: Citation from chapter “3.3 Design”: “The rectangular fields in between are filled with orchards (for details of the orchard management cf. chapter 4.3 The perspective of the farmers).”

Comment 24: “1680 25: You speak of irrigation canals but what about drainage canals?”

Response: Comment adopted. For explanation cf. to the response to comment 18:

Changes in the manuscript: For citations from chapters “3.3 Design”, “3.4 Key actors”, and “3.2 Site conditions” cf. to comment 18.

Comment 25: “1681 23: compulsory afforestation. What is the Chinese term (foot note)? Relation to yiwugong?”

Response: Comment adopted. For explanation cf. to the response to comment 04.

Changes in the manuscript: For the citation including the Chinese term also cf. to comment 04.

Comment 26: “1682 4: suggests the participation of “workers”: Did farmers not participate?”

Response: Comment adopted. The word “workers” has been exchanged for “manpower” and “workmen” to avoid misunderstandings. Farmers did not participate, as made clear in the same paragraph.

Changes in the manuscript: Citation from chapter “3.5 Compulsory labour”: “Even so, the mobilisation of manpower reached very high levels: About 70 different organisations and enterprises sent thousands of workmen twice a year, for periods of 8, 12 or even 30 days at a time (cf. Fig. 4).”

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Comment 27: “19: “drinking water facilities” Where did/does drinking water for the isolated farm houses come from? How was/is it produced and distributed?”

Response: Comment not adopted. Electric wells provide drinking water from deep ground water layers. However, we do not want to burden the paper with additional technical details.

Changes in the manuscript: None.

Comment 28: “1683 25: In 1987 the leasing of reforested land to individual farmers began in many parts of China. It was apparently part of a national policy.”

Response: Comment adopted. The national policy context has been added to chapter “4.1 The leasing system”.

Changes in the manuscript: Citation from chapter “4.1 The leasing system”: “In 1981, the State Council of the PR China had started promoting private forestry on a leasing basis by its “Resolution on Issues Concerning Forest Protection and Development” (guanyu baohu senlin, fazhan linye ruogan wenti de jue ding; for backgrounds cf. Delang and Yuan, 2015). In 1987, when the Kökyar afforestation work was still in the early stages, the Forest Management Station and Water Management Station reacted to this resolution and to the dire financial situation of their afforestation project, with the introduction of a leasing system that is fundamentally still in force today [...]”

Comment 29: “1685 1: how huge is huge? Can you give some approximate figures?”

Response: Comment adopted. Table 3, which presents exemplary area sizes of private main tenants, has been linked to the corresponding section. The word “huge” has been exchanged by the less emotional “large”.

Changes in the manuscript: Citation from chapter “4.1 The leasing system”: “They act as main tenants who first make the necessary infrastructure investments and then sublease their large estates in small patches to hundreds of leasing households, compensating their initial investment costs with income from the subleases (for exemplary

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area sizes of main tenants comp. Table 3).”

Comment 30: “11: What means “extreme temperature alleviation”? 13: “wind speed reduction”? Where is the evidence? Experiments in Central Europe suggest reductions in the immediate vicinity of tree rows, but not at more distant places. Theoretically there is “air humidification” because of the evaporating irrigation water. But does it have an impact on the downtown climate? “air filtration”: The proportion of large particles (“sand”) will probably be reduced due to their deposition within and behind the shelterbelt. But there will be almost no impact on the quantity of suspended particles/airborn particulate matter. “soil fixation”: This is an important question: Did the advocates of the project consider the shelterbelt site itself as a major source of wind erosion? Or did they assume that the neighbouring lands are the source of wind erosion? In case of the last supposition did the project initiators also consider a restoration of the natural shrub vegetation in the erosion area?”

Response: Comment adopted. The section on extreme temperature alleviation (capping of heat and cold peaks), wind speed reduction, and air humidification had been marked as an assumption. In response to the comment, we made the assumption character of this section more explicit (chapter “4.2 The perspective of Aksu citizens”). The actual effect of these ecosystem services on the climate of Aksu City has not been researched by this paper, however, since the fringes of the afforestation area touch the fringes of Aksu City, an effect in at least the neighbouring quarters is probable. We agree with the comment on air filtration. The shelterbelt site itself was indeed considered as a source of wind erosion. In response to this comment, we made this fact more explicit in chapter “3.2 Site conditions”. Also the neighbouring areas further in the north must be seen as a source of wind erosion. There exists a programme for reducing livestock densities in the surroundings which aims at protecting the sparse natural vegetation, which, in response to this comment, has been added to chapter “4.2 The perspective of Aksu citizens.” We do not have any information on active restoration of the natural vegetation.

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Changes in the manuscript: Citation from chapter “4.2 The perspective of Aksu citizens”: “Shelterbelts in drylands are generally assumed to provide vital regulating ecosystem services, such as air humidification and cooling, wind speed reduction, air filtration and soil fixation (Yimit et al., 2006; Halik, 2003; Chokkalingam et al., 2006).” Citation from chapter “3.2 Site conditions”: “The fluvial terrace itself is composed of brown desert soil lying upon a gravel bed. The grain size at the surface changes from sandy gravel in the north to sandy silt and clay in the south. A high groundwater table and the regional extreme evaporation rate result in an average soil salinity of 2.87% and pH-values of 7.1 to 9.0. Before the afforestation, the soil was predominantly devoid of vegetation, with some areas being sparsely covered by Alhagi spec. and other herbaceous plants. The barren soil of the Kökyar plateau was regarded as a major source of wind erosion, thus contributing to the regular northerly dust and sand storms in Aksu City (cf. Fig. 2; Kökyar Annals Compilation Committee, 1996; Aksu Prefectural Forestry Department and Kuqa Television Station, 2006).” Citation from chapter “4.2 The perspective of Aksu citizens”: “[...] the precise contribution of Kökyar to this positive development is hard to determine, since there are more contributing factors in addition to Kökyar, such as the extension of the irrigated agricultural area around Aksu, the protection of the natural vegetation in the surrounding deserts and semi-deserts by a programme which reduces livestock densities, and fluctuations in precipitation patterns (interview 2; Yimit et al., 2006; Yang and Cui, 2006).”

Comment 31: “15, 16: You speak of a “notable improvement of the dust and sandstorm situation”. This is a sweeping yet vague wording. It would be helpful and more convincing for the reader if you could briefly name some of the evidences provided by your sources.”

Response: Comment adopted. We rephrased the queried section in order to make the content of our sources more explicit and to avoid vague wording. Furthermore, to prevent questions and misunderstandings, we linked the following paragraph, which presents all the details of one of the sources, to the queried section.

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Changes in the manuscript: Citation from chapter “4.2 The perspective of Aksu citizens”. “An improvement of the dust and sand storm situation of Aksu City after the establishment of Kökyar Protection Forest is claimed by the Kökyar Annals (Kökyar Annals Compilation Committee, 1996; for details cf. next paragraph) and has been perceived and described by Kökyar farmers (socio-economic household survey 2012) and Aksu citizens (Aksu citizens interviews 2011; also cf. Halik, 2003).”

Comment 32: “28 how close is the “immediate vicinity”?”

Response: Comment not adopted. Immediate means, the forest begins where the city ends, as displayed in Figure 2.

Changes in the manuscript: None.

Comment 33: 26 “wind born sand events” Could you provide a precise definition? Until now the reader has the impression, that the authors feel quite fine with the data provided by their sources. It is only now – rather late – that one learns more about the ambiguity of the sources, the terms and data.

Response: Comment adopted. For the term “wind-borne sand event” cf. to the response to comment 10. In response to this comment and to comment 10, we erased the expression “wind-borne sand event” from the text, except for chapter “4.2 The perspective of Aksu citizens”, where its ambiguity is discussed. Additionally, at its first appearance in this chapter, we have set it in quotation marks. Furthermore, we added a general comment on potential biases of the Kökyar Annals in chapter “2. Methods”.

Changes in the manuscript: For changes in chapter “1.2 The geographic conditions of Aksu City” cf. to comment 10. Citation from chapter “4.2 The perspective of Aksu citizens”: “The first volume of the Kökyar Annals illustrates the Kökyar effect by presenting figures for reduced “wind-borne sand events” (fengshaci) in three periods between 1954 and 1990 (cf. Table 4; Kökyar Annals Compilation Committee, 1996).” Citation from chapter “2. Methods”: “Since all these sources were written or produced under

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the aegis of persons and organisations involved in the establishment process of the Kökyar Protection Forest, there is a certain danger of biases in favour of the project.”

Comment 34: “1686 26 – 27: Earlier I asked for more detailed information about the local topography and site conditions: It is only now, that you inform the reader, that the project is located on “the largest dust fields in the region”. But then, it would be helpful to learn more about the characteristics of a “dust field” and the local dust fields in particular (proportion of clay/silt particles mixed with or without sand???)”

Response: Comment adopted. In response to this comment and comment 02, the section of the introduction, describing the geographic conditions of Aksu City, has been enlarged and upgraded to a separate subchapter (chapter “1.2 The geographic conditions of Aksu City”). Furthermore, chapter “3. The establishment of Kökyar Protection Forest” has been enlarged by a subchapter which describes the topographic, pedologic and hydrologic details of the Kökyar afforestation site (chapter “3.1 Site conditions”).

Changes in the manuscript: For citations of chapter “1.2 The geographic conditions of Aksu City” and chapter “3.1 Site conditions” cf. to comment 02.

Comment 35: “Table 2: Which year do you take as the base year for the inflation adjustment?”

Response: Comment adopted. As already had been described in chapter “2. Methods”, the base year is 2014. For the convenience of the reader, the year has now additionally been added to all concerning tables.

Changes in the manuscript: The base year 2014 has been added in brackets to Table 2, 3, 5, 6, 7, and 8. Exemplary citation from table 2: “Adjusted for inflation (2014) [million CNY]”

Comment 36: “Table 4: The figures must be explained.”

Response: Comment not adopted. The figures are already explained in detail in chapter “4.2 The perspective of Aksu citizens”. The combination of text and tables will

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become easier to read once the tables are inserted into the text at the right places.

Changes in the manuscript: None.

Comment 37: "Figure 2 should be reproduced turned by 90 degrees (vertical arrow pointing towards North) and enlarged to better read the informations provided (contour lines). This map should be combined with a wind diagram.

Response: Comment adopted. The figure has been turned, enlarged, and combined with a wind diagram.

Changes in the manuscript: The changed Figure 2 will be presented at the very end of this reply. It cannot be displayed in a bigger size in this online format.

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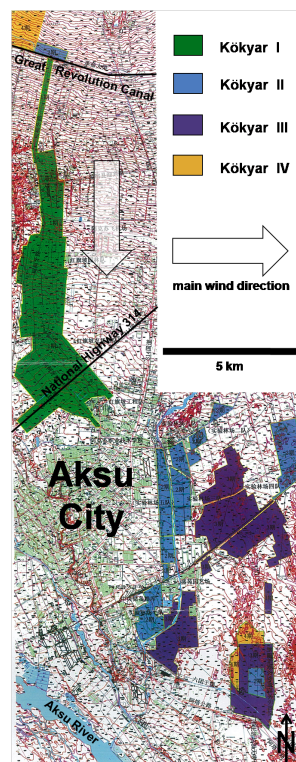


Fig. 1. The project areas of Kökyar I, II, III, and IV (partial view; adapted from Kökyar Annals Compilation Committee, 2006).

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