Trench with recently planted pine seedlings (Pinus sylvatica) in Saralanj community (Kirchmeir, H.)

High-altitude afforestation for erosion control (亚美尼亚)

描

Afforestation is a key technologies to protect soil against erosion and provide a wide range of ecosystem services. In this case, afforestation at high altitudes, which is particularly challenging, with the primary purpose of erosion control were planted in small patches with different methods. They form the basis for future community forests in Armenia.

Forests are - in terms of biomass accumulation and stability - the most successful ecosystems in the world. Natural forest ecosystems offer multiple ecosystem services, such as timber and fuel wood provision, water purification, carbon sequestration. In mountainous landscapes, forests have an additional protective function against erosion and natural hazards (e.g., avalanches, landslides, debris flows or rock falls). In the South Caucasus, two natural limits restrict forest expansion: at 2.300-2.600m a.s.l. the upper tree line is visible, whereas steppe and semi-desert ecosystems form the lower tree line.

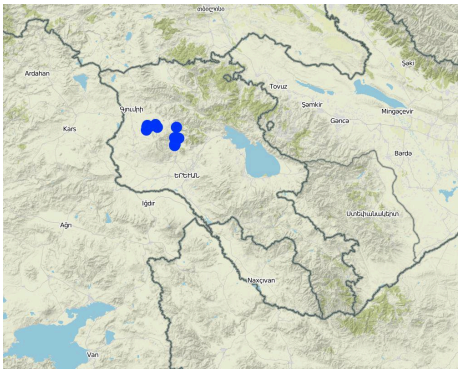
Socio-economic and geo-physical living conditions:
The intervention area is located at the northern to eastern slopes of Mount Aragats (4013m). The villages are located at 1600 to 1800 m above sea level where the slope meets a plain with stepic soils and crop production while the slopes of the mountains are used for livestock grazing (sheep and cattle).

Purpose of afforestation:
By means of afforestation of degraded pastures, mountainous areas that suffer from erosion and overgrazing should be rehabilitated and erosion protection capacity enhanced. At the same time, the afforestation sites should form the basis for future community forests providing a wide range of ecosystem services, a concept that has not yet been established in Armenia.

Implementation
Between 2014 and 2017 more than 200 hectares were fenced for afforestation, 145 ha were actively afforested in 10 different communities around Mount Aragats in Armenia. The average size of the 20 plots is 10 ha (35 ha being the largest site, 1 ha the smallest one). The afforestation included different species combinations, planting schemes and methods to determine most cost-efficient afforestation methods for Armenian conditions. All afforestation took place at elevations between 1900 and 2300 m.a.s.l.. The afforestation included fencing of the area to protect the afforestation site against grazing, the preparation of the planting sites according to fixed planting schemes, the actual planting in lines with trenches, single plant holes and group plantings. For some sites, additional irrigation was established for the first years. Particular attention was paid to the species selection which explicitly included fruit trees and shrubs to ensure local economic returns.

Practical experiences
A wide range species was tested. Within the given climate context, pine (Pinus sylvestris), the main non-native species as well as native maple (Acer trautvetteri), Persian Oak (Quercus macranthera) and birch (Betula litwinowii) showed the best results. Particular attention was paid to adapted species to create resilient forest-shrubland with a large number of tree species. In general, planting in trenches shows highest survival rates. Bare root system and containerized seedlings were used for planting. Containerized seedlings definitely provide better survival rate in comparison with bare root system seedlings. Additionally, mulch cover was provided to protect seedlings and keep soil humidity. The main maintenance measures are repeated mulching and weed control and irrigation during the first 3 years. Furthermore, some replanting is continuously taking place as the sites are facing tough environmental conditions (hot summers, drought, short vegetation period).
The plantation was organised and supervised by local NGO's (ATP Armenian Tree Project, ESAC Environmental Sustainability Assistance Center) in close cooperation with the local village population. In a Memorandum of Understandig between the Armenian Ministry of Territorial Administration and Development, the local village administration and GIZ the share of payed labour and own contribution was fixed beforehand.

地点



地点: Lusagyugh, Saralanj, Harich, Arayi, Quchak, Hnaberd, Mets Manatash, Pokr Mantash, Nahapetavan, Shirak and Aragatsotn Marzes, 亚美尼亚

分析的技术场所数量: 10-100个场所

选定地点的地理参考

- 44.03408, 40.60734
- 44.15521, 40.61765
- 44.38562, 40.61728
- 44.03523, 40.63233
- 44.13295, 40.64011
- 44.05501, 40.61872
- 44.02974, 40.61975
- 44.36409, 40.44722
- 44.371, 40.45878
- 44.41472, 40.51481
- 44.02905, 40.59833
- 44.0215, 40.59193
- 44.36129, 40.5197
- 44.36186, 40.45786

技术传播: 均匀地分布在一个区域 (approx. < 0.1 平方千米 10 公)

实施日期: 不到10年前 最

介绍类型

- 土地使用 的创新
- 作为传统系统的一 分 50 年
- 在实 /研究期
- 外 目 干

Impacts and perception
After the first years already first successes are becoming visible contributing to increased vegetation cover, increased biomass and improved soil protection. The communities are proud to be amongst the first in Armenia with a community forest. However, slow growth will require continuous commitment and care on behalf of the community.

Planting of different tree seedlings in trenches in Arayi, Armenia (Kirchmeir, H.)

Oak (Quercus macranthera) planted in a hole to protect seedling (Kirchmeir, H.)

技术分类

主要目的

- [ ] 改 生产
- [x] 减少、 、恢复土地 化
- [x] 保护生态系统
- [ ] 结合其他技术保护流域/下游区域
- [x] 保持/提 生物多样性
- [ ] 低灾害
- [ ] 应气候变化/极端天气及其影响
- [x] 减缓气候变化及其影响
- [ ] 创 有益的经济影响
- [ ] 创 有益的社会影响

土地利用

牧场 - 粗放式放牧场: 半游牧/游牧
主 动物种类及产品Cattle and sheep

森林/林地 - 植树 林棍交品种
产品和服务: 林水果和坚果, 放牧/啃牧, 然灾害 护

供水

- [ ] 养
- [x] 混合 水灌溉
- [ ] 充分灌溉

每年的生长季节数: 1
该技术实施前的土地利用: The afforestation sites were previously used as (partly overgrazed) pastures for grazing of mainly cattle. Thus, this technology included a land-use change from grassland/pasture to forest/shrubland.
牲畜密度: 1-2/ha

土地退化相关的目的

- [x] 止土地 化
- [x] 减少土地 化
- [ ] 修复/恢复严 化的土地
- [ ] 应土地 化
- [ ] 不 用

解决的退化问题

土壤水蚀 - Wt 土流失 侵, Wg 冲沟侵/沟

生物性退化 - Bc 植 盖的减少 和物种多样性的下

SLM组

- 天然和半天然森林管理
- 区域封 停止使用 支持恢复
- 减少基于生态系统的灾害

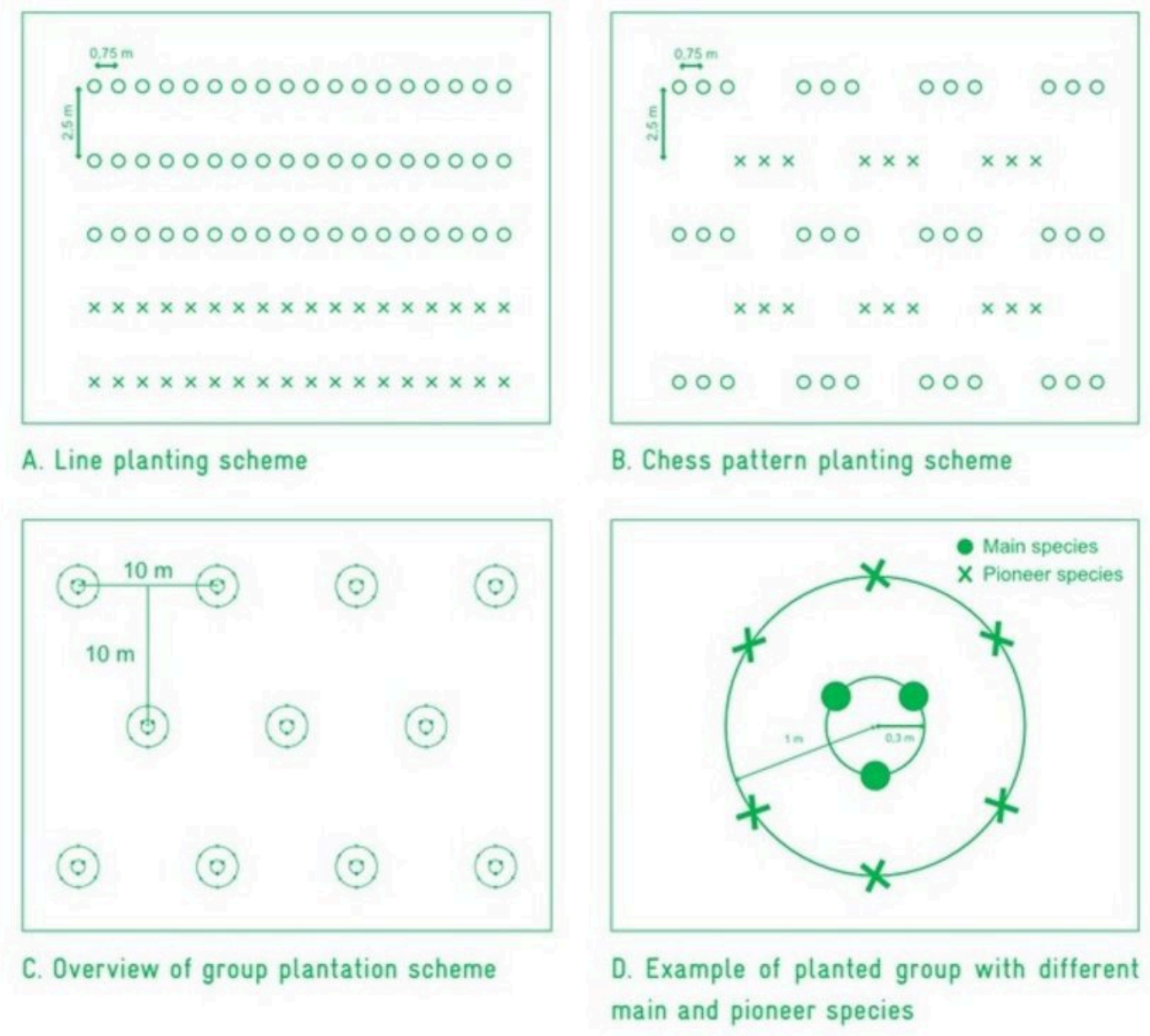
SLM措施

植物措施 - V1 乔木和灌木 盖层

管理措施 - M1 改变土地使用类型

技术图纸

技术规范



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Needed resources for 1 ha afforestation:
- 2.000-5.000 seedlings
- 10-50 t water (for initial irrigation)
- 40 – 100 working days
- Shuffles or soil driller
- Means of transport

Selection of species
It is recommended to use different local tree species for any afforestation activity, as they can cope best with the given environmental conditions and, therefore, are more resilient towards pests and climatic variations. Most suitable species for afforestation:
-Trautvetters maple (Acer trautvetteri)
-Birch (Betula letwinowii)
-Wild Oriental Apple (Malus orientalis)
-Scott's Pine (Pinus sylvestris var. hamata)
-Persian Oak (Quercus macranthera)
-Raspberry (Rubus idaeus)
-Mountain ash (Sorbus aucuparia)
For selecting suitable species, screening of the wider project area is essential in order to prepare a list of species, which would naturally grow under the given ecological conditions

Planting scheme
The technical drawings describe different potential planting schemes. A further figure describes the advantages and disadvantages of each scheme.

Planting season
The climate in the South Caucasus region shows low precipitation rates in the summer period. As seedlings have a small root system, young trees are more sensitive to drought. The best time for planting is either autumn or early spring as during autumn, winter and spring, more moisture is available that helps the seedlings to develop deeper root systems to survive during summer droughts.

Fencing
In many cases, afforestation sites are located on pasture land. To protect the planted seedlings from browsing by livestock or wild game, it is recommended to fence the afforestation site before starting the plantation of the seedlings.

Planting
The planting process is specified in one of the technical drawings. With a hole driller planting of one tree takes 2-4 minutes, planting by hand 8-10 min. Each seedling is waterered with an intial 5-10 l of water.

Fig. 7A: Oak seedlings in a trench plantation

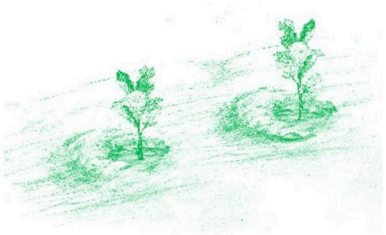

Fig. 7B: Oaks planted in plant holes

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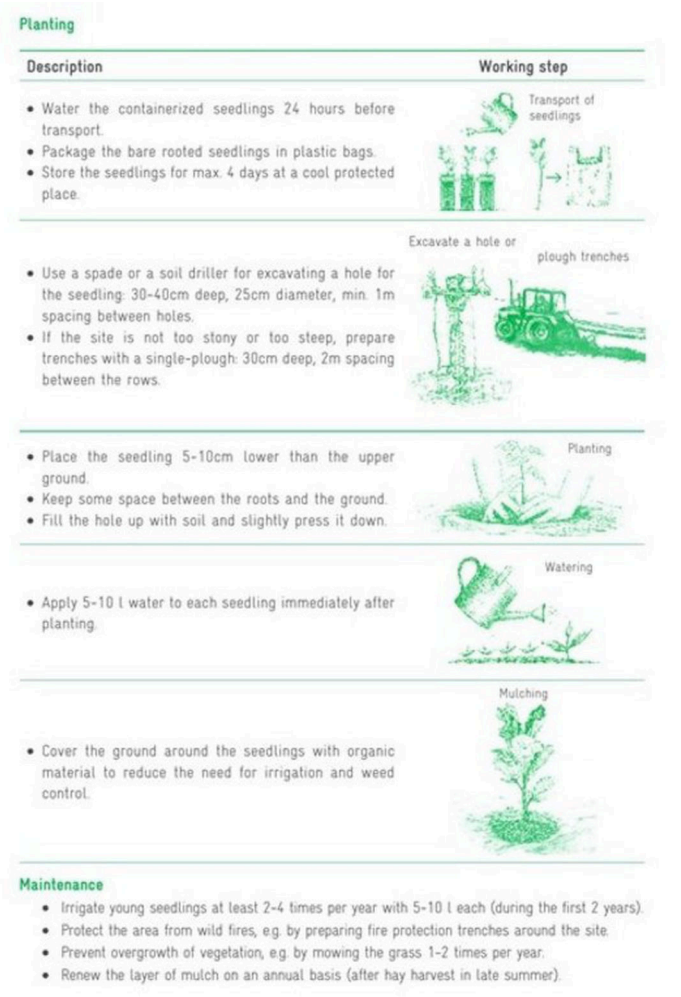

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技术建立与维护 活动、投入和 用

投入和成本的计算
- 算的成本为 每个技术区域 尺寸和 积单位**ha**
- 成本 算使用的 **美元**
- 汇率 换算为美元 1 美元 = 不 用
- 用劳工的每日平均工 成本 不 用

影响成本的最重要因素
With costs of approximately 5,700 USD/ha including fencing (30%), planting (30%) and seedlings (40%) afforestation is very intensive in financial resources. It is very likely that these high costs will limit the upscaling of the afforestation process. There are some options to reduce costs: •Fence large areas and try to have sites in square or circle shape •Increase number of seedlings planted by person by using soil-drillers •Use cheaper fencing material (e.g. game protection fence, poles without concrete) •Reduce seedling number to 2000-3000 seedlings/ha •Using seeds (e.g. oak) instead of seedlings •Regrow seeds in local low-cost nurseries (e.g. Lusagyugh)

技术建立活动
1. Selection of afforestation site, plantation scheme and species (时 / 率anytime)
2. Fencing of the area (if area is being grazed or wild game is browsing seedlings (时 / 率before planting)
3. Prepare and transfer seedlings to the site (时 / 率before planting)
4. Excavate whole for the seedling (30-40cm deep, 25 cm diameter, 1m spacing between wholes) (时 / 率autumn, early spring)
5. Place the seedling and fill hole with soil (时 / 率autumn, early spring)
6. Apply 5-10 l of water immediately after planting (时 / 率after planting)
7. Cover soil around seedling with mulch and organic material (时 / 率after planting)

技术建立的投入和成本 (per 1 ha)

对投入进行具体说明	单位	数量	单位成本 (美元)	每项投入的总成本 (美元)	土地使用者承担的成本%
劳动力					
Local workers for plantation of trees	seedlings	2500.0	0.27	675.0	10.0

Installation of fence and posts	person day	191.0	12.3	2349.3	
设备					
Equipment (hummer, driller, etc.)	set	1.0	141.8	141.8	30.0
植物材料					
Tree seedlings	pieces	2500.0	0.31	775.0	
Mulching	kg	1250.0	0.03	37.5	
施工材料					
Fencing (permanent mesh wire fence)	meter	317.0	1.35	427.95	10.0
Irrigation system	set	1.0	889.0	889.0	15.0
Metal posts for fence (1.8m)	pieces	106.0	2.97	314.82	
sand	kg	3444.0	0.012	41.33	
Other material(electrode, wire armature, metal disc)	set	1.0	386.9	386.9	20.0
Cement	kg	1148.0	0.12	137.76	
其它					
Transporation of mulch	time	1.0	102.8	102.8	
Transporation of construction materials	time	5.0	92.5	462.5	
Transporation of workers to the field	time	15.0	30.2	453.0	
Transporation of seedlings	time	1.0	51.4	51.4	
技术建立所需总成本				**7'246.06**	

技术维护活动

1. Irrigation of young seedlings with 5-10 l (时 / 率2-4 times per year for the first two years)
2. Preparation of fire protection trenches (时 / 率f needed)
3. Mowing to prevent overgrowth of seedlings (时 / 率1-2 times per year)
4. Renew mulch layer (时 / 率annually after hay harvest in summer)
5. Replanting of seedlings (10% each year) (时 / 率annually to be done for the first 5 years)

技术维护的投入和成本 (per 1 ha)

对投入进行具体说明	单位	数量	单位成本 (美元)	每项投入的总成本 (美元)	土地使用者承担的成本%
劳动力					
Irrigation of young seedlings with 5-10 l	Man/day	1.0	10.0	10.0	100.0
Preparation of fire protection trenches	rm	150.0	0.34	51.0	100.0
Mowing to prevent overgrowth of seedlings	Man/day	4.0	10.0	40.0	50.0
Renew mulch layer (including mulch value)	Man/day	5.0	10.0	50.0	50.0
植物材料					
Seedlings for replantation (including labour)	seedlings	1200.0	0.51	612.0	50.0
其它					
Petrol for irrigation	liter	7.0	0.8	5.6	
技术维护所需总成本				**768.6**	

然环境

年平均降雨量

- [ ] < 250毫米
- [ ] 251-500毫米
- [x] 501-750毫米
- [ ] 751-1,000毫米
- [ ] 1,001-1,500毫米
- [ ] 1,501-2,000毫米
- [ ] 2,001-3,000毫米
- [ ] 3,001-4,000毫米
- [ ] > 4,000毫米

农业气候带

- [ ] 潮湿的
- [ ] 半湿润
- [x] 半干旱
- [ ] 干旱

关于气候的规范

以毫米为单位 算的年平均 521.0
Precipitation peak between May and June.
气 站名称Aparan, Aragatsotn Marz, Armenia
According to Köppen and Geiger, the climate is classified as Dfb (Cold/continental, no dry season, warm summers). Annual mean temperature is 5.2 °C. The warmest month of the year is August, with an average temperature of 16.4 °C. January has the lowest average temperature of the year with -6.9 °C.
based on data from the following source:
https://www.arcgis.com/home/webmap/viewer.html?layers=3ac478a468c245ef9bfd5533f7edbf93

斜坡

- [ ] 水平 0-2%
- [x] 缓 3-5%
- [x] 平缓 6-10%
- [ ] 滚坡 11-15%
- [ ] 崎岖 16-30%
- [ ] 峭31-60%
- [ ] 常 峭60%

地形

- [ ] 原平
- [ ] 山
- [x] 山坡
- [ ] 山地斜坡
- [x] 坡
- [ ] 底

海拔

- [ ] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [x] 1,501-2,000 m a.s.l.
- [x] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

.....应用的技术

- [ ] 凸形情况
- [ ] 凹 情况
- [x] 不相关

土壤深度

- [ ] 常浅0-20厘米
- [x] 浅 21-50厘米

土壤质地（表土）

- [ ] 粗粒/ 砂
- [x] 中粒 壤土、粉土

土壤质地（地表以下>20厘米）

- [ ] 粗粒/ 砂
- [x] 中粒 壤土、粉土

表土有机质含量

- [ ] 3%
- [x] 中 1-3%

- [ ] 中等深度（51-80厘米）
- [ ] 深（81-120厘米）
- [ ] 非常深（> 120厘米）

- [ ] 细粒/□□□粘土

- [ ] 细粒/□□□粘土

- [ ] 低（<1%）

地下水位
- [ ] □□上
- [ ] < 5米
- [x] 5-50米
- [ ] > 50米

地表水的可用性
- [ ] □□
- [ ] 好
- [x] 中等
- [ ] 匮乏/没有

水质（未处理）
- [ ] □好□用水
- [x] 不□□用水□□□处理□
- [ ] 仅供农业使用□灌溉□
- [ ] 不可用

盐度是个问题吗？
- [ ] 是
- [x] 否

洪水发生
- [ ] 是
- [x] 否

物种多样性
- [ ] □
- [x] 中等
- [ ] 低

栖息地多样性
- [ ] □
- [ ] 中等
- [x] 低

应用□技术的土地使用□的特征

市场定位
- [ ] 生□□□给□
- [x] 混合□生产/商业
- [ ] 商业/市场

非农收入
- [ ] 低于全□收入的10%
- [x] 收入的10-50%
- [ ] > 收入的50%

相对财富水平
- [ ] □常□疼
- [x] □疼
- [x] 平均水平
- [ ] 丰富
- [ ] □常丰富

机械化水平
- [x] 手工作业
- [ ] 畜力牵引
- [x] 机械化/电动

定栖或游牧
- [x] 定栖的
- [ ] 半游牧的
- [ ] 游牧的

个人或集体
- [ ] 个人/家庭
- [x] 团体/社区
- [x] 合作社
- [ ] 员工□公司、政府□

性别
- [x] 女人
- [x] 男人

年龄
- [ ] 儿童
- [ ] □年人
- [x] 中年人
- [x] □年人

每户使用面积
- [ ] < 0.5 公□
- [ ] 0.5-1 公□
- [x] 1-2 公□
- [x] 2-5公□
- [ ] 5-15公□
- [ ] 15-50公□
- [ ] 50-100公□
- [ ] 100-500公□
- [ ] 500-1,000公□
- [ ] 1,000-10,000公□
- [ ] > 10,000公□

规模
- [x] 小□模的
- [ ] 中等□模的
- [ ] 大□模的

土地所有权
- [ ] 州
- [ ] 公司
- [x] 社区/村庄
- [ ] 团体
- [ ] 个人□未命名
- [ ] 个人□有命名

土地使用权
- [ ] □由□入□无组织□
- [x] 社区□有组织□
- [ ] 租□
- [ ] 个人

用水权
- [ ] □由□入□无组织□
- [x] 社区□有组织□
- [ ] 租□
- [ ] 个人

进入服务和基础设施的通道

健康	疼	好
教□	疼	好
技术援助	疼	好
就业□例如□农□	疼	好
市场	疼	好
□源	疼	好
□□和交□	疼	好
□用水和卫生□施	疼	好
□□服务	疼	好

影响

社会经济影响

□料生产

□□增加

森林/林地□□

□□增加

□木材林业生产

□□增加

产品多样性

Within the fenced afforestation site, the grass could be cut and used as hay. The protection from grazing helps biomass development which leads to better protection from Surface water Erosion and this lead to soil-regeneration and increase of productivity.

The natural forest was removed for the purpose of grazing and the forest cover will be now re-established on the afforestation sites.

We mixed shrub species like raspberries and fruit-trees (wilde plumb) between the main tree species to create short time Benefit for the village people.

In addition to the wide spread grazing land use now the hay

增加

production in the fenced afforestation site is increased for the first 1-2 decades (until the canopy is too dense) and the collection of berries and fruits give additional income opportunities. In the Long terme fuel wood production can be expected from the forested land.

生产区域 /使用中的新土地

增加

The grazing range is limited by the fenced afforestation site. This is relevant in the first couple of years before hay or fruit/berry productivity is able to fully compensate the loss of grazing range.

工作

增加 低

The maintenance of the afforestation site lead to increase of workload especially in the first 2-4 years when hay cutting and Irrigation is needed until the tree seedlings are well established.

社会文化影响

娱乐机会

减少 改

As there is almost no forest near to the villages every woodland is very attractive for recreational purpose, but it will Need 2-3 decades until this function will be fulfilled by the afforestation site.

SLM/土地 化知

减少 改

The local stakeholders got hands on training on fencing, afforestation and maintenance of afforestation sites.

生态影响

地 径流

增加 低

The fencing of the afforestation site immediately stops the heavy grazing Impact which leads to fast recovery of the Vegetation. The improved Vegetation cover and better development of the root System reduce Surface water run of Speed and increase water Infiltration.

发

增加 低

An increase of vegetation and the leaf area index will lead to an increase of evaporation.

土壤流失

增加 低

Increase of vegetation cover and reduction of water runoff will lead to decrease of soil loss.

土壤有机物/地下C

增加

The increase of vegetation leads to an increase of root development. Additionally, the increase of vegetation produces more litter, as no grazing is applied. The increase in litter leads to an increase of an humus layer and therefore to more below ground carbon.

植 盖层

增加

Especially the fencing leads to fast increase of vegetation cover.

生物 /地上C

增加

The local stakeholders got hands on training on fencing, afforestation and maintenance of afforestation sites.

植物多样性

增加

The stop of grazing and the new micro-habitats created by the shadow of the tree seedlings have let to an increase in plant diversity. This process might be reverse when the tree canopy is closed and less light is available for the herb-layer, but this will take several decades.

栖息地多样性

增加

The plain grasslands habitats are diversified by patches of forest.

场外影响

缓冲/ 滤 力 按土壤、植 、湿地划分

减少 改

The decrease of water run off increase the water capacity of the habitat and the afforested area will provide increase buffer capacity in the case of intensive rainfalls.

力搬 沉积物

增加 减少

The high grass and trees reduce wind speed at ground level.

成本效益分析

与技术建立成本相比的效益

短期回报 常消极 常积极

期回报 常消极 常积极

与技术维护成本相比的效益

短期回报 常消极 常积极

期回报 常消极 常积极

In the first decade the efforts on maintenance are high and it can be expected that the return of natural resources (hay, berries, fruits) is significantly lower the the maintenance efforts. As soon the trees are established and larger than 1.3 the root system is well establish and the trees are resistant to droughts, no vegetation cutting is needed and even game or cattle browsing will not necessarily lead to lethal damage.

气候变化

气候有关的极端情况（灾害）

局地 暴 常不好 常好

局地 灾 常不好 常好

局地 暴 常不好 常好

昆 / 侵扰 常不好 常好

其他气候相关的后果

延 生 期 常不好 常好

用和 应

采用该技术的地区内土地使用者的百分比

- [x] 单例/实
- [ ] 1-10%
- [ ] 10-50%
- [ ] 大于 50%

在所有采用这种技术的人当中，有多少人在没有获得物质奖励的情况下采用了这种技术?

- [x] 0-10%
- [ ] 10-50%
- [ ] 50-90%
- [ ] 90-100%

最近是否对该技术进行了修改以适应不断变化的条件？

- [x] 是
- [ ] 否

drought-adapted species, adaptation of planting schemes

什么样的变化条件？

- [x] 气候变化/极端气候
- [ ] 不断变化的市场
- [ ] 劳动力可用性 例如 由于 移

结 和吸取的教

长处: 土地使用者的观点

- Extension of forest cover of communities, new habitat for wild creators, forest will be a fire wood and non timber products source for local inhabitants, attraction of tourists into the communities, increased water regulating function, improved soil quality, increased vegetation, microclimate formation function, wind velocity reduction, reduced land degradation, nice view of the area due to afforestation,increased fodder for cattle
- empowerment of the local capacities on sustainable land management
- successful demonstration of erosion control measures

长处: 编制者或其他关键资源人员的观点

- Diversification of land use options for local stakeholders. Future options for sustainable firewood supply, non-timber forests products (berries) and recreation
- Option to use grass from cutting in between as fodder/hay production
- side-effect of fencing is increase in biodiversity of grassland species due to exclusion from grazing.

弱点/缺点/风险: 土地使用者的观点如何克服

- Reduces pasture land of community, which was converted into a forest Villagers/farmers need to increase the amount of hay from their homestead gardens using irrigation

弱点/缺点/风险: 编制者或其他关键资源人员的观点如何克服

- strong need for care taking in the first years community commitment, strong ownership
- Expensive due to high costs for fencing Consider alternative, cheaper fencing methods (e.g. wildlife protection fence)
- Complicated decision making processes by the project More mandate given to the implementing NGOs

参 文献

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WOCAT数据库中的完整描述
https://qcat.wocat.net/zh/wocat/technologies/view/technologies_4101/

链接的SLM数据
Approaches: Afforestation/Tree planting https://qcat.wocat.net/zh/wocat/approaches/view/approaches_2587/
Approaches: Sustainable managements on pasture and forest lands based on natural regeneration by electrified fences https://qcat.wocat.net/zh/wocat/approaches/view/approaches_2451/

文件编制者

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- Integrated Biodiversity Management, South Caucasus (IBiS)

主要参考文献
- Handbook on Integrated Erosion Control A Practical Guide for Planning and Implementing Integrated Erosion Control Measures in Armenia, GIZ (ed.), 2018, ISBN 978-9939-1-0721-9: GIZ Armenia

链接到网络上可用的相关信息
- Project website of the GIZ program: http://biodivers-southcaucasus.org/