Food and Agriculture Organization of the United Nations

ODI

Green jobs in agrifood systems

Setting a vision for youth in the Sahel

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Food and Agriculture Organization of the United Nations
Rome, 2023

Required citation:

Wiggins, S., Newborne, P., Benoudji, C., Diarra, M., Kane, N., Kiebré, M.B. & Sangaré, S. 2023. *Green jobs in agrifood systems – Setting a vision for youth in the Sahel*. Rome, FAO. https://doi.org/10.4060/cc7033en

ISBN 978-92-5-138002-4


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Boxes, figures and tables

Acknowledgements

This study was developed by Steve Wiggins and Peter Newborne from ODI, with research partners in the region, Colette Benoudji, Mamadou Diarra, Nene Kane, Marie Bernadette Kiebré and Saadatou Sangaré, as part of the FAO project *Building resilience in the Sahel region through job creation for youth*, funded by the Federal Ministry of Food and Agriculture of the Federal Government of Germany.

Coordination and technical guidance to the development of the study was provided by Francesca Dalla Valle, Programme Officer at FAO's Inclusive Rural Transformation and Gender Equality Division (ESP) and coordinator of the project.

We would like to express our deepest gratitude for inputs and support to Boubacar Moumouni Kaougé, Head of the Sustainable Development and Climate Change Division, and Kouldjim Guidio, Head of the Resilience and Human Development Department, both at the G5 Sahel Secretariat, Dalia Abulfotuh (FAO Regional Office for the Near East and North Africa), Melisa Aytekin and Caesar Vulley (FAO Regional Office for Africa), Madi Savadogo (FAO Burkina Faso), Hilaire Nare Mallah (FAO Chad), Issa Keita (FAO Mali), Seriba Konare (FAO Mali), Oumou Niang (FAO Mauritania), Bachir Maliki (FAO Niger), Abdou Salifou (FAO Niger), Makie Yoshida (FAO Office of Climate Change, Biodiversity and Environment) and Beatriz Guimarães Almeida and Peter Wobst (ESP).

Thanks also go to all those across the G5 Sahel countries who supported the study during the key informant interviews.

Equally, we thank Camilla Toulmin from the International Institute for Environment and Development, and Chris Reij from the World Resources Institute, for their comments and insightful inputs.

Thanks are also due to Bartoleschi/BVC associati for the design and to Marco Fiorentini (ESP) for providing assistance.

Abbreviations and acronyms

AfDB	African Development Bank
ANEREE	Agence nationale des énergies renouvelables et de l'efficacité énergétique (Burkina Faso)
ARSE	Autorité de régulation du secteur de l'énergie (Burkina Faso)
CEAS	Centre écologique Albert Schweitzer (Burkina Faso)
DCF	Devolved Climate Finance
ESP	Inclusive Rural Transformation and Gender Equality Division (FAO)
FAO	Food and Agriculture Organization of the United Nations
GCF	Green Climate Fund
GDP	gross domestic product
GGW	Great Green Wall
IEA	International Energy Agency
ILRI	International Livestock Research Institute
IMF	International Monetary Fund
IMROP	Institut Mauritanien de recherches océanographiques et de pêches
IPCC	Intergovernmental Panel on Climate Change
ISFM	integrated soil fertility management
LESE	Laboratoire des études sociales et économiques
LUCC	land-use and land-cover change
MODIS	moderate resolution imaging spectroradiometer
NDC	nationally determined contribution
NGO	Non-governmental Organization
NTFP	non-timber forest product
O&M	operation and maintenance
SAED	Société d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et de la vallée de Falémé

Units of measurement

GW	gigawatt
GWh	gigawatt hour
ha	hectare
km	kilometre
km^2	square kilometre
kWh	kilowatt hour
kWp	kilowatt peak
m	metre
m^2	square metre
m^3	cubic metre
Mtoe	million tonnes of oil equivalent
MW	megawatt

Extended summary

Background: motivation, questions and approach

Populations in the G5 Sahel countries are growing rapidly, in the Niger for example, by as much as 3.7 percent a year and in Mauritania by 2.6 percent. Consequently, most people are young. Given these large cohorts of young populations, over the next five years 11.4 million youth will turn 16 years old, and most will then start to seek jobs in the region. The workforce is projected to grow by 4.4 percent a year (World Development Indicators, 2021). **If these young job seekers do not find decent employment, the option may be to migrate out of necessity, with also a potential vulnerability of falling into negative coping mechanisms.**

Most current employment in the G5 Sahel is in agriculture, in cropping and herding and in the associated agrifood supply chains. Although the countries are urbanizing, meaning that future economic growth may be faster in industry and services than in agriculture, in the short and medium run the bulk of new jobs are likely to be created in the agriculture sector and its supply chains.

G5 Sahel countries should also transform their economies over the medium term to be environmentally sustainable and adapt to a changing climate, with emissions of greenhouse gases reduced to net zero in order to enter into a green transition. Key environmental concerns in the region include the degradation and erosion of soils, wetlands and woodlands (including deforestation) and the conversion of valuable habitats such as forest and wetlands to crop or grazing land, leading to loss of biodiversity.

For the five countries of the G5 Sahel – Burkina Faso, Chad, Mauritania, Mali and the Niger – this study aims to address the following questions: i) What employment can be created for youth, as agriculture and the agrifood value chains become environmentally sustainable as part of a rural green transition?; and ii) What policies, programmes and investment are needed to create these jobs and ensure that young women and men can access them?

The study also considered the switch in rural energy to renewable sources because, even if the energy sector is not usually considered as part of agriculture, such changes will affect the lives of farmers, fishers and herders and rural populations at large. Furthermore, future agrifood value chains are likely to increase their use of energy for pumping, processing, cooling and transportation and these changes will provide new jobs, green jobs also, that may be available for youth.

Identifying what a rural green transition would entail for the five countries, has proven to be a considerable challenge. Most of the efforts in the study went into establishing how many jobs might be created and their nature. **Through available literature and key informants interviews, the study identified a set of six axes of transition which are in common in the five countries:**

1. **Rural solar energy** – for household use, for processing agricultural produce and for powering irrigation pumps.

2. **Irrigation**, above all small-scale irrigation – either household plots or village-level schemes.

3. **Environmentally sustainable and climate-smart agriculture**, the latter with a focus on adapting to a changing climate.

4. **Restoration of collective lands** that have suffered degradation through loss of trees and bushes, soil erosion, etc.

5. **Fisheries – capture fishing from rivers and lakes and aquaculture** from purpose-built ponds in countries and, in Mauritania, ocean fisheries.

6. **Recycling of rural waste**.

Once these had been defined, the remaining task as part of the study, was to investigate further the likely jobs and what would be necessary for youth to be able to access them.

Findings

Axis 1 – Rural solar energy

Energy for rural areas will switch from non-renewable to renewable sources. In a first phase, this will see electricity from hydroelectric plants and from solar photovoltaic panels provide power for household lighting, cooking and running appliances, for pumps, and probably for some rural workshops. In a second phase, probably in the medium to long term, electricity from hydro and solar may power rural transport, replacing fossil fuels.

Moves to renewables are already underway, some hydro plants are running in the region, and solar panels are becoming quite common in towns and villages. The potential for hydro plants is though limited due to issues related to the availability of suitable sites on rivers, instead, the potential for solar is large and widespread, given the abundant sunlight that the Sahel receives. For example, the *Desert to Power Initiative* of the African Development Bank (AfDB) envisages the Sahel becoming a world centre of solar power.

For rural solar power, power may be provided by means of village plants serving a mini-grid for the local area, by individual household roof-mounted panels, and by solar panel arrays for irrigation and water pumps. If half the 10 million rural households of the G5 Sahel use solar electricity, some 791 megawatt (MW) of capacity would need to be installed, at an estimated capital cost of EUR 7.6 billion. Employment created would be 247 413 person-years for installation and thereafter 98 965 persons per year to operate and maintain the plants (see Table 3.1 in the main text).

Axis 2 – Irrigation

Irrigation is part of any green rural transition. It allow farmers to control water, reduces their dependence on variable rains and helps them adapt to a changing climate. By giving farmers more control over water, irrigation increases the productivity of other farm inputs – fertilizer, seed and, above all, human labour. **Economically speaking, irrigation can raise crop production and generate greater returns per hectare (ha).**

Only a small share of the area to arable crops in the G5 Sahel countries is currently irrigated: 230 000 ha out of 36 million ha of arable land. Furthermore, only 14 percent of the estimated potential to irrigate has been developed. Governments along the years have declared their intention to expand irrigation, for example the *Dakar Declaration on Irrigation* of 2013 aimed for 800 000 ha to be irrigated by 2020 in the five countries with another 570 000 ha that could be further developed in the 2020s.

A key issue at stake is the scale of irrigation: large public sector schemes, such as the 100 000 ha of the Office du Niger, a semi-autonomous government agency in Mali, tend to cost more to develop per ha, and to be harder to maintain and operate, than small-scale schemes at farm and village level. Technical advances, above all solar-powered pumps, promise to facilitate the development of irrigation at small scale.

Irrigation usually greatly increases the demand for labour on fields. A somewhat broad estimation of the potential to create jobs assumes an average of two more full-time equivalent jobs per ha. Hence, irrigation of another 570 000 ha could potentially generate 1.14 million jobs on the fields alone – this is not counting extra jobs in providing inputs and services to irrigators, in collecting, processing and transporting extra produce, or additional jobs in the rural economy that arise when farmers spend additional income. In addition, there would probably be demand for technicians to service and repair irrigation equipment.

To expand irrigation, it will be necessary to invest capital in works and equipment. In small-scale development, cash costs typically come to around USD 5 000 per ha, so the total investment for the expansion contemplated would amount to USD 2.85 billion. Given that farmers would make much of the investment, they would need access to lines of credit to do so.

With such an expansion of irrigation, a potential hazard is that of overabstraction of surface water or groundwater. To avoid this, a collective effort is needed at catchment and aquifer level to monitor water use and ration it if necessary. Given limited state capacity to manage such arrangements at central level, more localized arrangements may be needed, using local observations of river flows and water levels in wells.

Axis 3 – Farming

Farming needs to become environmentally sustainable and climate-smart, and adapted to a changing climate and with reduced emissions of greenhouse gases. In the Sahel, the priorities are to conserve soil and water, to avoid conversion of valued habitats to crop farming and to adapt systems to a climate expected to be much warmer, with more – and considerably more varied – rain.

Since the 1980s, farmers in parts of the Sahel, above all in Burkina Faso and the Niger, have been conserving their soil and water, through stone bunds, semicircular levees and zai pits, in large part local innovations. They have also been regenerating trees on their fields. These changes have taken place over millions of ha, a success that is not as well recognized internationally as it deserves to be.

Conservation pays, through higher yields on treated fields and through avoided future degradation of soils. Estimates of benefit–cost ratios range from 5:1 to 10:1, showing very high returns indeed. Although large areas have been treated, considerable additional areas would benefit from conservation. If another quarter to one-third of the arable land were to be treated, this would create a great deal of employment, between 4.5 million and 5.9 million full-time equivalent jobs for construction and from 380 000 to 737 000 jobs in annual maintenance. Much of this work is manual labour; ideally, it would be possible to mechanize the most arduous jobs, such as digging zai pits. That might create the potential for youth to acquire the machinery through leasing and then to hire out their services to farmers.

Although many of the benefits of conservation accrue to farmers, some positive externalities are created, above all when carbon is captured in soils and trees.

Axis 4 – Land restoration

Land restoration closely complements the previous axis of transition, with the difference that it applies first and foremost to common lands rather than fields belonging to households. **Landscapes across the Sahel have changed considerably over the past century**; while it is far from clear that increasing human pressure has degraded most of the land, this has been the case for some lands: tree and shrub cover has been lost, as some crop fields have been overworked, leading to loss of soil and nutrients.

Moreover, governments in the Sahel, and the international bodies that support them, recognize land degradation to be serious and have resolved to remedy it. Various initiatives are implemented in support of land restoration, among others, the *Bonn Challenge* aiming at restoring degraded and deforested lands, the *African Forest Landscape Restoration*, which supports the *African Union Agenda 2063* and, further, one of the most known, the *Great Green Wall (GGW)*, implemented in all along the Sahel. All these initiatives fit within the *United Nations Decade of Ecosystem Restoration (2021–2030)*.

To restore and enhance the commons, increased vegetation is needed starting by conserving soils and water, then either planting trees or allowing seeds from native trees to grow.

A look at how to do this reveals two competing visions. One is to set national targets for restoration and reforestation then implementing this through central agencies, using local people as casual labour. This top-down approach too often disempowers and alienates locals, so that measures taken are not maintained: typically, many trees planted do not survive. The alternative is to start locally, giving more power and agency to villages and communes to undertake the measures they would like to see for their commons. Strong arguments support a decentralized approach. This can be seen in the way that ideas on the GGW have changed from early conceptions of the wall as the engineering of a forest barrier no more than few kilometres wide, to the wall becoming a metaphor for enhancing landscapes across a much broader swathe of landscape.

The value of restoration lies partly in the value of higher yields for crops in agroforestry fields, in forest products – wood, fruit, etc.; partly in enhanced functioning of the ecosystem and partly in avoiding the considerable costs of land degradation[1].

National targets for land restoration can be high. Mali aims to regenerate and reforest 5 million ha, and restore degraded land and consolidate sand dunes in over 3 million ha. By 2030, the Niger has targeted planting up and restoring forests on 2.8 million ha, managing another 2 million ha of forests, encouraging agroforestry on 1 million ha of croplands and restoring 1.5 million ha of degraded land.

For the Niger, an estimate of the total of full-time jobs in establishing and planting is of a little more than 1 million over the seven years remaining on the country's targets – an annual average of 150 000 full-time equivalent jobs – and annual maintenance work of 486 000 jobs, so 636 000 jobs a year in all. If the Niger's ambitions were replicated over the other four countries, then as many as 3.18 million jobs a year would be created across the G5 Sahel.

Land restoration may already be policy across the G5 Sahel but implementing it requires both capital and organization. Investment costs for the Niger are estimated at capital costs of USD 2.1 billion, or USD 301 million per year over 7 years, and

USD 1.2 billion in annual maintenance. Unless international funds are more forthcoming, this may well be beyond the means of the Nigerien government.

[1] Estimated as potentially costing the Niger USD 30 billion over 30 years. Estimates of benefit-cost ratios for restoring land are high: from 2.5:1 for restoring woodland to more than 6:1 for cropland and more than 7:1 for wetlands.

The organizational challenge is no less formidable: to plan and implement works across millions of ha requires many field workers. **Moreover, land rights are critical to land restoration.** Local people will restore their fields and commons only if they feel that these are their lands, from which they reap benefits and over which they can set rules on usage – for example how much firewood members of the community can remove from local forests, how much stock can be grazed on the commons and how those livestock are to be controlled to prevent damage to fields. Added to this are the rights of nomadic and transhumant pastoralists to move their livestock seasonally, for which they need agreed routes and rules. Without agreements on this, conflicts between farmers and herders can break out.

In parts of the Sahel, rights to common lands are not well defined. Overlapping sets of norms are set by different jurisdictions, from the central government to communes to village councils. Arriving at a fair consensus on land rights requires discussion and negotiation among those with longstanding claims, this may not be simple but it can be done, as field experiences from Burkina Faso and the Niger demonstrate. Care and patience with rights, preferably with devolution of powers to local forums, can be allied with land restoration to reduce the menace of violence.

Axis 5 – Fisheries

Fisheries could represent another potential green opportunity, even though four of the countries are landlocked, the large rivers and lakes of the region mean that fishing could be an opportunity in generating jobs, as assessed for example, in Chad. Some potential exists to expand fisheries, including aquaculture and farming fish. Small-scale fish farming may be integrated with other farm activities, using crop by-products and waste to feed the fish.

While evaluating the potential for fisheries development and additional jobs has proved elusive, as fisheries activities are not well recorded in national statistics, nor are their economic or social characteristics reviewed for the study[2], fisheries has been included among the axis, due to the noted potential in generating jobs as assessed in the country reports by key informant interviews (see the summary matrices in Appendix A).

Across four of the G5 countries[3], a broad estimate of additional jobs comes to 160 000 – valuable employment but an order of magnitude lower than the estimates for the other axes of transition.

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2 Literature searches show articles on the biology and ecology of fish in the G5 Sahel but rarely on fisheries as an economic or social activity.

3 No estimates were available for Burkina Faso.

Axis 6 – Recycling rural waste

Recycling rural waste was identified as part of a rural green transition axis for all five countries (see the summary matrices in Appendix A). Waste and by-products from plants, animals and kitchens may be converted to compost or to organic charcoal. **Such recycling will create some new jobs albeit few in comparison with the other axes. When rural households recycle waste, they are unlikely to hire additional people to do so.**

When employment is created in primary sectors, this will lead to multipliers in the rural economy. For example, pumps and solar panels create a demand for technicians to repair and maintain equipment; additional farm output creates jobs in trading, processing and transport while extra income spent locally generates demand for services, such as for example construction and catering. To reflect this, we have applied a multiplier to jobs of 1.3, taking values reported in the literature.

Summing the potential employment estimated for the four main axes of transition, it may be possible to create 8.2 million (full-time equivalent) jobs in investments and installation and in operation and maintenance (O&M) in annual terms, adding in another 30 percent for jobs created rurally through multipliers (Table A).

This may be put against the projected entry of 11.4 million new entrants to the labour force over 5 years and 24.8 million over 10 years (see Section 1.1 of the main text).

Clearly, a rural green transition could make a large contribution to meeting the demand for work.

Table A **Summary of potential employment creation across the G5 Sahel countries to 2030**

Axis	Installation (a)	Installation annual equivalent over 7 years (b = a/7)	Operation and maintenance annual (c)	Total annual employment (d = b + c)
Rural solar power	247 413	35 345	98 965	134 310
Irrigation				
• Farm work	5 700 000	814 286	1 140 000	1 954 286
• Technical support	–	–	2 850	2 850
Environmentally sustainable and climate-smart agriculture	3 200 000	457 143	560 000	1 017 143
Land restoration	5 181 500	740 214	2 430 750	3 170 964
Total		2 046 988	4 232 565	6 279 553
Apply multiplier, 1.3		–		2 661 083.84
Grand total				**8 163 418**

Source: Author's own elaboration.

Implications and policy recommendations

Five key points stand out, as follows:

1. **Most of the changes needed are already underway to some extent**: in no case does a transition depend on a radically new activity requiring skills and competencies scarce in the Sahel. **The need is not to start new things but to accelerate what is, in some places, already in progress.**

2. **For some activities, the populations of the G5 Sahel countries are already leaders in innovation**, even if this is not always widely known. In seeking guidance and expertise to take such measures forwards, learning from the best and most innovative famers and learning from local leaders should provide technical lessons and inspiration.

3. In certain aspects, **the Sahel has the potential to lead the world – above all with solar energy.**

4. **Many of the changes require neither central direction by the state nor large-scale public funding** – with one notable exception. Key drivers of change will be demand from rural households accompanied by firms seeking business and

profit – solar energy and irrigation being excellent examples. Rather than trying to drive (or control) such change, the state needs to accompany, monitor and nurture it, acting where it needs to act: to resolve problems of collective action and to provide public goods.

5. **The exception comes with land restoration**, where some of the value of improvements accrues as public goods and externalities whose benefits reach well beyond the field or village boundary – biodiversity and carbon capture being global public goods. These benefits also persist well beyond the usual horizon of business planning, whereby returns are expected within five or so years. **A strong case can be made for public investment in these activities.** Moreover, given that some benefits are international, they should be funded in considerable part by international agencies and funds.

On **employment and the prospects for youth**, four questions arise.

1. Will these jobs be accessible by youth? Of the 8.2 million jobs, the great majority involve work on the land, in the fields, on the commons. The skills needed are largely those familiar to anyone raised on a farm, in a village. That said, these skills are largely tacit skills that older generations need to pass down to youth. The danger is that youth may discount such knowledge as something from a bygone age.

Some jobs will require technical skills. For solar energy installation and O&M, technicians need to know (some of) the science that lies behind the technology; they need instruction in the practical skills necessary to install and maintain the panels. To back up an expansion of irrigation, to support farmers conserving and enhancing their land and to accompany local groups working to restore their local landscapes, more extensionists will be needed. In addition to training in agronomy, ecology and forestry, such technicians need orientation on working with people to facilitate processes – for example to chair farmer field schools – rather than to instruct farmers by rote learning.

2. Will these jobs be accessible by young women? Only a few jobs call for unusual physical strength, the rest can be done by either sex. That said, many of these activities will be seen as men's work because, variously, they call for strength or they involve skills – such as electrical or mechanical abilities – that some think to be masculine. Few of the jobs are seen as jobs for women, the exceptions being unenviable tasks such as weeding fields or laboriously pricking out tree seedlings.

Overcoming rigid conceptions of jobs partitioned by gender often needs a medium- to long-term effort and to ensure women exercise their roles, any role, including leading ones, quotas for example could be applied.

3. Will these jobs be well paid and attractive to youth? The stark answer is that most of the jobs on the land will not be well paid and some youth will disdain them for that and for overall being associated with farm labour and its negative perception. The technical jobs instead are those that will probably attract rural youth.

Two closely related things need to be noted. One is that farm wages in parts of the world where economic growth has been relatively strong over the past 40 years have been rising – as has been seen in East and Southeast Asia. The other is that, as labour becomes short, jobs on the land become mechanized – a process facilitated by Asian industrialization reducing the real costs of machinery for farms and villages. Inexpensive pumps, cultivators and motorcycles are commonplace today in some parts of the global south, even this seemed unlikely a generation ago. Some of them can already be seen in the Sahel, cheap irrigation pumps and motorcycles for example. Many of these green jobs may initially require manual effort for low pay but with time – and assuming sustained economic growth – wages will rise, and machinery will increasingly be used to ease the work.

4. Will these jobs be accessible by youth living with disability? Most of the employment considered here requires physical abilities, work on the land is not well suited to people with restricted mobility. Their prospects for employment will lie more with jobs created through multipliers, in services demanded by farmers and fishers with more income from their activities.

Recommendations

Transitions can look daunting to leaders facing the pressing demands of everyday business. Yet, some straightforward actions can drive change.

As some changes are already underway, driven by individuals, households, farms and firms, consult with those in the vanguard of change. Consulting leaders, managers and others who are already making the changes, to gain their thoughts on matters critical to public policy, may well be more productive than commissioning further studies or drawing up comprehensive plans that add only minor details to what is already known.

Some of what is needed may not require costly or difficult state action, it may instead just need some obstacle to be removed – for example exempting green inputs from a tax, cancelling a subsidy or deleting some excessive or unnecessary regulations.

Certain changes require only making progress on already existing priorities. For example, farmers wishing to irrigate their lands, need access to capital. Efforts to improve rural finance are longstanding – encouraging formal savings, lubricating credit and overcoming the market failures[4] that separate deserving farmers from the small loans they need.

Specific suggestions

To promote solar energy, work with industry – with importers or sellers of equipment – to deal with any bottlenecks and blockages. Supply chain forums that bring together importers, installers, electricity companies and representatives of consumers with government, can be a way to identify problems and opportunities, and to discuss potential solutions.

Where international public goods are being created, assess the possibility to access the *Green Climate Fund (GCF)* and other such vertical funds to finance certain activities. In particular, obtaining carbon payments for farmers who capture carbon should be a prime goal, even if it may take some years to achieve. It is unlikely any one government will be able to make sufficient progress on this: instead, form networks and working commissions across Africa to combine ideas and to put pressure on donors and international funds to take action. Within Africa there are centres of thinking that can take this forward, like for example, Akademiya, Alliance for Green Revolution in Africa (AGRA), the Forum for Agricultural Research in Africa, the Consultative Group for International Agricultural Research centres, the United Nations Environment Programme (UNEP), etc.

Some tasks that may be needed to forge the link between the funds and actions on farms and villages may be attractive jobs for youth – for example advising farmers and village councils on how they may qualify for payments, helping source any technical help they need; and monitoring, verifying and reporting on what has been done in the field. Such jobs could be rewarding for youth determined to lead in the fight against global heating.

If farmers and communities can be paid for their services on behalf of their nations, their region and the world as a whole, apart from the financial reward this should help promote pride in Sahelian achievements – which deserve more appreciation across Africa and beyond. The combination of payments with a sense of pride may well inspire local youth to value the knowledge and innovations of older

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[4] Above all, the reluctance of banks to give loans to farmers when they do not know anything about the latter's competence and moral character.

generations, and possibly interest them in following their footsteps and building upon and improving what their parents and grandparents have achieved.

Reorient existing extension staff in agriculture and forestry agencies, towards greener practices and towards working alongside farmers is advisable. If necessary, encouraging them in taking pride in local innovations, recognizing the considerable achievements of Sahelian farmers in pioneering ways to conserve soil and water.

Looking locally for innovation does not, and should not, lead to ignoring formal science. Important advances have been made in recent times using sophisticated technology to understand natural resources in the Sahel – in detecting land use change through remote sensing, in assessing groundwater supplies through magnetic resonance soundings, in understanding teleconnections in regional climates allowing for much improved weather forecasting. The insights from these advances need bringing together with understandings at field level: a role exists for local and regional think-tanks to broker the two domains of knowledge – and to steer the scientists towards addressing priorities as seen from below, to prompt them to ask better and more productive questions.

Decentralize any public spending on land restoration as far as possible, instead of spending through central ministries, give more to communes, empower them to take decisions and provide technical support – so they can devise what needs to be done locally to restore local landscapes, with all the adaptations to context this entails. In the 2010s, trials of decentralized climate finance were undertaken in Mali and Senegal that showed that this could be done. Decentralization may produce disparate local practice, and sometimes will lead to failure but it may equally lead to unexpected successes – hence the following recommendation.

Invest in monitoring change in rural areas, reviewing what is changing, why and how. Look for innovations being tried in the field to find better ways of working, with even greater benefits. **Do not underestimate or ignore the ingenuity and drive of some local actors – as they are a key asset in making the green transition.**


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Introduction: why this study?

This study concerns the intersection of two broad issues. One is about creating jobs, decent jobs and green jobs, to meet the demand for jobs for a growing and young population. The other is about making the transition from economies that are not environmentally sustainable to economies that are sustainable, hence "green" economies. The setting for these issues is the G5 Sahel countries – Burkina Faso, Chad, Mauritania, Mali and the Niger – and, specifically, their agriculture and associated agrifood value chains.

The study addresses the twin questions of: what employment can be created for youth, as agriculture and the agrifood value chains transition to become environmentally sustainable? And what policies, programmes and investments are needed to create these jobs and ensure that youth, all youth including young women, can access them?

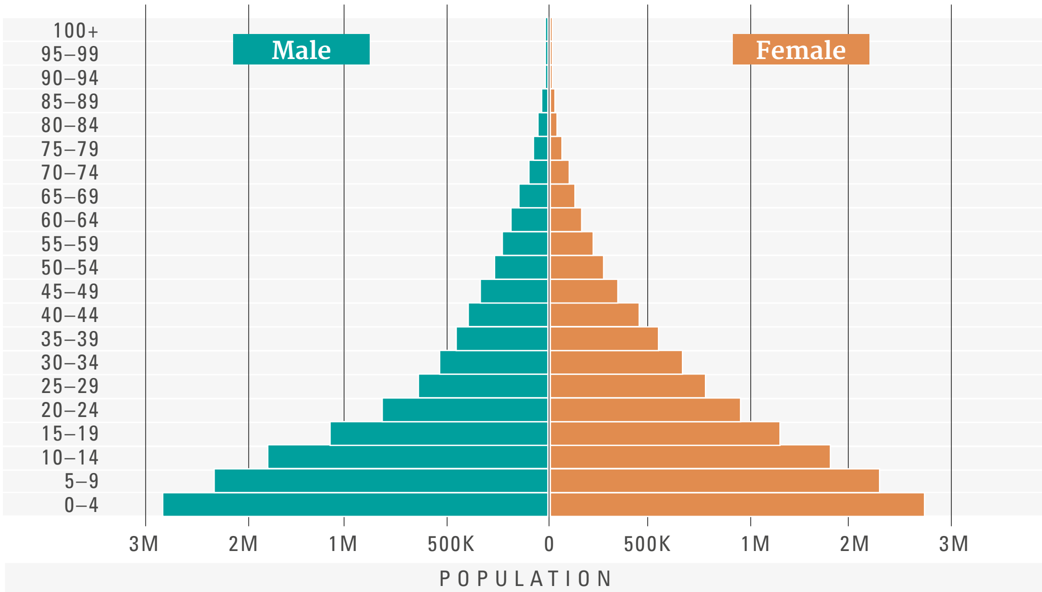
1.1 The challenge of youth employment in the G5 Sahel

Creating employment, and more specifically decent jobs for youth in the G5 Sahel countries is a pressing concern.

Some 91 million people were living in the G5 Sahel countries in 2021, of whom 70 percent (63 million) still lived in rural areas (World Development Indicators, 2021). **Populations are growing rapidly: between 2000 and 2021, the population of the G5 Sahel almost doubled.** Population growth rates remain high, between 2.6 percent a year in Mauritania and 3.7 percent a year in the Niger. These are among the fastest growing populations anywhere in the world.

Consequently, the age structure of the population is skewed towards youth, see, for example, the age pyramid for Mali (Figure 1.1). Youth aged 15–24 years old, as per United Nations (UN) youth ageframe definition, numbered 18 million in 2022: if we assume that, as for the whole population, 70 percent live in rural areas, rural youth numbered 12.6 million.

Figure 1.1 **Age pyramid, Mali, 2022**

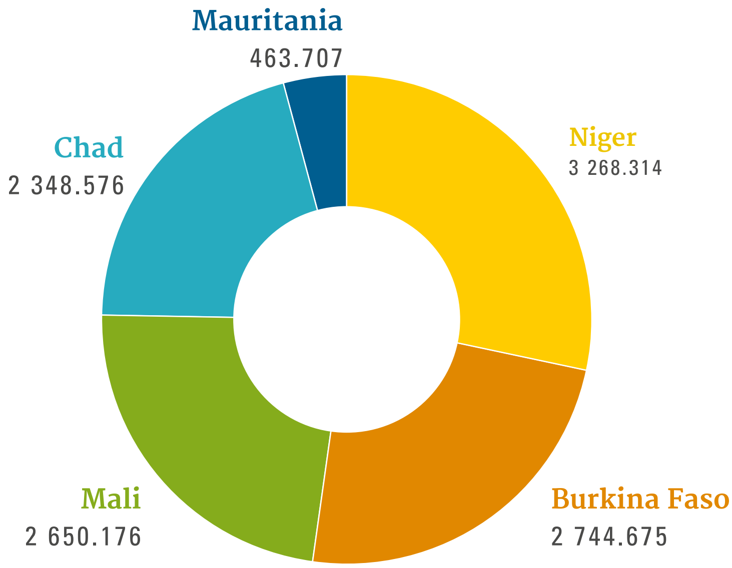


Source: US Census Bureau. 2022. ***International Database***. International Programs Center. Washington, DC. [Cited March 2023]. www.census.gov/data-tools/demo/idb/#/country?COUNTRY_YEAR=2022&COUNTRY_YR_ANIM=2022&FIPS_SINGLE=ML

Given large cohorts of children, between 2022 and 2027 in the G5 Sahel 11.4 million youth will turn 16 years old, and most of them will then begin to seek jobs (Figure 1.2). This means 24.8 million over the next 10 years. In late 2022, the workforce of the region was expanding by 4.4 percent a year.

Creating decent jobs for new young workers, while improving conditions and remuneration for those already in work, is an economic and social challenge. The danger is that, if too few jobs are created, youth will slip into un- and under-employment, and that many of the jobs created will have poor conditions and low pay, so that youth end up in working poverty. If this happens, disgruntled youth may either migrate out of necessity, seeking work elsewhere – perhaps swelling the numbers trying to cross the Mediterranean – or turn to crime and insurgency.

Figure 1.2 **New entrants to the job market in the G5 Sahel from 2022 to 2027**



Source: Authors' own elaboration based on 2022 age cohort data from the US Census Bureau.

The main source of employment currently in the G5 Sahel is agriculture, both crop farming and herding. In most of the five countries, more than 60 percent of the workforce is engaged in these activities, which generate between 18 and 42 percent of the gross domestic product (GDP) in the five countries (World Development Indicators, 2022). **In addition, a substantial, but uncounted, number of people are employed in the supply chains that link the fields and herds to the towns and cities** – chains in which they trade, transport and process farm produce, or deliver inputs such as seed, fertilizer and veterinary medicines (Haggblade, Hazell and Reardon, 2007).

Over the short and medium terms, agriculture, and its associated supply chains, will probably continue to generate more jobs than other sectors, even if services and industry grow faster. Furthermore, agriculture can generate jobs close to where most people, especially those on low incomes, currently live: in rural areas.

Hence, a key issue is how to generate decent jobs in agriculture and agrifood value chains effectively and economically, and how to ensure jobs pay better and provide better conditions than existing ones.

1.2 What is a green transition in the G5 Sahel?

G5 Sahel countries, in common with the rest of the world, must transform their economies over the medium term to be environmentally sustainable, and especially to be adapted to a changing climate and with emissions of greenhouse gases reduced to net zero. This is what we understand as a "green transition".

In more detail, and specifically for agriculture and food value chains, the changes include reducing the harmful impacts of farming, herding, forestry and fishing on natural resources and the environment. Potential problems to correct include degradation and erosion of soils, wetlands and woodlands (including deforestation); conversion of valuable habitats such as forest and wetlands to crop or grazing land (leading to loss of biodiversity); overdrawing of water from aquifers or from surface water systems endangering the functioning of ecosystems; depletion of fish stocks; and pollution of soils, water and air through runoffs of agricultural chemicals used to control pests and disease, excess use of fertilizer leading to nitrate pollution of water and disposal of animal waste into streams.

These changes can also help enable agriculture to be better adapted to a changing climate, and reduce greenhouse gas emissions from agriculture. Section 3.3 of the study presents more details on what specifically needs to be done in this respect for agriculture.

Part of any green transition for agriculture and the agrifood value chains will concern use of energy, and the need where possible to change from fossil fuels to renewable sources. Most energy use in rural areas is for household needs: cooking and lighting. Although such changes may not be only agricultural, they have been included here because they concern the lives of farmers, fishers and herders and because future agrifood chains are likely to make increasing use of energy for pumping, processing, cooling and transport.

To note that the study has not considered other green changes in rural economies and societies, such as correcting harm from mining as these activities are not part of agriculture and the agrifood systems.

In what follows we adopt the term "rural green transition" to embrace what we have considered, even if we have not examined all things rural. In practice, and in most parts of the rural Sahel, these matters constitute the bulk of all things that would change to be environmentally sustainable in rural areas. Decent jobs for young people forming part of this green transition are "green jobs" for these purposes.

2

Approach, framing and methods

2.1 Approach

A challenge for this study was to establish what a rural green transition might be in the five countries of the G5 Sahel. The G5 Sahel is physically large – more than the area of Western Europe – and has 91 million inhabitants (United Nations Population Division, 2022). A rural green transition has several and diverse dimensions, with plenty to consider for each of these dimensions. Identifying what might be the main changes in the transition, what they would involve and what their dimensions might be – and hence how many jobs, and what kinds of jobs, might be created – required much study, involving matters from solar power to land restoration, and crossing boundaries of professional specializations.

The study team was aware of the challenges, and hence planned to spend at least half the time available to define the transition. Given that doing this was a precondition to answering questions on whether and how youth could take up the jobs in the areas of activity identified as key to the green transition in the region, priority was given to this first step. This meant prioritizing the demand side of employment (job creation), over the supply side (by educating and training the potential workforce). The priority has some reason: if jobs are not created, no amount of skilling and training of youth will allow them to access employment.[5]

[5] This point has been made in the recent literature. For example, Mwaura and Glover (2021), in reviewing initiatives on green jobs for youth in Africa, report that most policy attention has been on the supply side, on skilling and training youth for potential green employment, rather than on the creation of those jobs. A World Bank team reviewing employment presented their approach at ODI, London, in late 2022: they stressed that the critical issue was creating demand for workers.

2.2 Mapping green transition and employment opportunities

To map the elements of rural green transition, the team began with insights from the literature to create a framework that differentiated between employment in the public sector and that in households and private firms, and between new jobs and increased employment in existing jobs. As evidence was collected, it became clear that, while the former distinction between public and private was useful, the latter, between new and existing employment, was less so.

In each country, available literature was reviewed and key informants in government, private firms and civil society were interviewed to build a picture of the more substantive changes that would be part of a rural green transition. Further, to the above a framework established six axes of transition:

1. **Rural solar energy** – for household use, for processing agricultural produce and for powering irrigation pumps.

2. **Irrigation**, above all small scale irrigation – either household plots or village-level schemes.

3. **Environmentally sustainable and climate-smart agriculture**, the latter with a focus on adapting to a changing climate.

4. **Restoration of collective lands** that have suffered degradation through loss of trees and bushes, soil erosion, etc.

5. **Fisheries** – capture fishing from rivers and lakes and aquaculture from purpose-built ponds in countries and (in Mauritania) ocean fisheries.

6. **Recycling of rural waste.**

These categories overlap and complement one another. Solar energy, for example, can power irrigation pumps. Restoring collective lands and making farming on households plots sustainable involve complementary synergies. For example, more trees on collective lands reduce wind speed locally to the benefit of crop fields; a restored landscape is likely to capture more rainfall for local aquifers, raising water levels in irrigation wells.

Few of these changes directly affect pastoralism, a major occupation in the drylands of the Sahel. The reason for that is that, when herders are allowed their longstanding nomadic and transhumant movements, pastoralism is very largely environmentally sustainable.

2.3 Further investigation

With the mapping in place, the team then looked to establish the changes likely for each of the six axes. This involved establishing the scale of change that might be seen, for example, if more irrigation was needed, over what area would it be?

After this, the team addressed the question of how much employment might be created by the scale of change contemplated, the kinds of jobs these would be and the requirements involved in youth taking them up. In each country, national researchers looked to any published sources and interviewed key informants to gain further knowledge and info. The aim was to produce, for each country, a matrix that would summarize, for each axis: i) The activities and scale envisaged and the employment likely per unit, for example per ha irrigated; ii) The conditions necessary to create the change and the jobs; and, iii) The need for experience and training to take up the jobs. Appendix A of the study presents the five matrices. To note that where detailed information was not available, the task involved making (reasonable) assumptions to fill the more important gaps.

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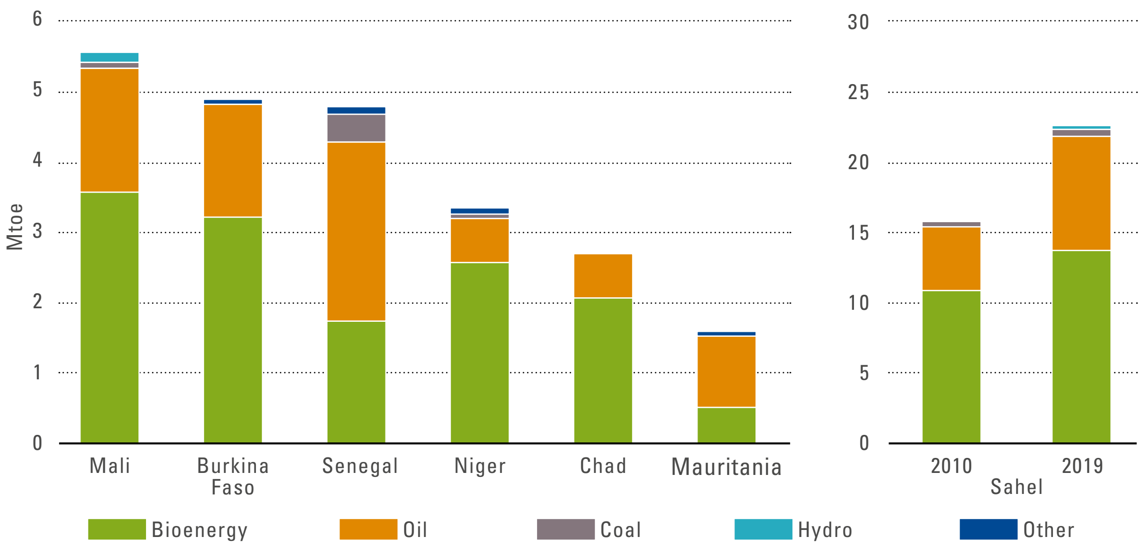
3 Findings

3.1 Renewable rural energy

A substantial transition in rural areas of the G5 Sahel will see energy switch from non-renewable to renewable sources. Currently, most of the rural energy used comes from biomatter (i.e. fuelwood, charcoal) used for cooking and heating. In some affluent rural homes, gas cylinders provide cooking fuel and kerosene may be used for lighting. Motorized transport runs on diesel and petrol. Some rural workshops may have generators to provide electricity.

National statistics (data on rural energy were not found) show the importance of biomatter energy and oil for the economies of the Sahel (Figure 3.1).

Figure 3.1 **Primary energy demand in the G5 Sahel countries plus Senegal, 2019**



Source: IEA. 2022. *Clean energy transitions in the Sahel*. Paris, IEA.

Most current non-renewable energy can be replaced by renewable energy: hydroelectricity, wind, solar power and biogas.

The transition will probably take place at varying paces: already some rural homes are lit by solar panels and some hydroelectric plants provide electricity. Within the next ten years, considerable expansion of solar power for homes, irrigation pumps and agro-processing and the installation of hydro plants on rivers with potential energy and sites that can be dammed, are likely (IEA, 2022). Other changes instead may take longer and may require more investment.

At least one large initiative is underway to produce hydroelectricity: the *Kandadji Dam*, situated 180 km upstream of Niamey, in the Niger. When the first phase of the initiative will complete, the dam will have the capacity to generate 130 MW of electricity. Further, a subsequent increase in the height of the dam is planned to bring that capacity up to 230 MW. That would allow for the generation of 660 gigawatt hour (GWh) of electricity. In 2015, electricity output in the Niger was 531 GWh, growing at almost 7 percent a year; this means that, by 2022, it should have reached 848 GWh. When the Kandadji dam starts generation in 2025, it should provide more than half the electricity consumed in the Niger.

Opportunities to develop hydropower at scale are, however, limited to large rivers and to places where these can be dammed at economical cost.

Biodigesters may become another source of rural energy. Mali has plans for 5 000 units of 2–4 m^3 capacity each.[6]

The rest of this section looks at the potential of solar power, an energy source that can be developed almost everywhere across the G5 Sahel, and for which the cost of harnessing power through photovoltaic cells has been falling rapidly over the past ten or more years (Lazard, 2021).

3.1.1 What measures are needed?

The case for solar power rests not only on the abundance of sunlight across the Sahel but also on its low emissions of greenhouse gases. Moreover, rural communities can use solar to generate power from small-scale units located where the power is needed – on the roof of a house or workshop, next to an irrigation pump, next to a borehole. Solar power does not require long transmission lines – a boon in the Sahel, where rural population density is relatively low so reaching villages involves long power lines per household served.

[6] *Source*: Mali country report in Appendix A.

The first step would be to convert the source of current electricity from fossil fuel to solar energy, after that, solar offers the potential to considerably expand the coverage of electricity. In the rural Sahel, few households have access to mains electricity: estimates range from under 10 percent for all our countries of the G5 except for Mali, where 23 percent of rural households had electricity in 2015 (World Bank, 2023).

At least two models of provision are contemplated: household solar kits and village solar plants, as described below in this section.

A second stage of energy transition would be more ambitious, and that would be the conversion of rural transport to electric vehicles, powered by batteries charged by local solar plants. This may not take place by 2030, given the capital costs of replacing the vehicle fleet and of installing solar-powered charging points. It is, however, a tantalizing prospect – a Sahel that would then be almost entirely self-sufficient in energy, with next to no imports of fossil fuels.

In what follows, the study will consider only the first phase, that of electrification of rural homes.

3.1.2 What is the potential to create new jobs?

The potential to create new jobs depends on the scale of rural electrification: the numbers of households that might be served and their consumption. We assume that, with relatively cheap solar energy, half of rural households across the Sahel will electrify.

Across the G5 Sahel there are over 10 million rural households. If half of these are served with electricity, at 455 kWh a year (the unit consumption projected for the GFC project in rural Mali: GCF, 2019), then some 791 MW of solar plant would need to be installed.

The capital investment, taking the unit capital cost of solar power provision in rural Mali planned for the GCF Mali solar rural electrification project of EUR 9.64 million per MW of installed capacity, comes to EUR 7.6 billion. Employment created would be 247 413 person-years to install, and thereafter 98 965 persons per year to operate and maintain the plant (Table 3.1).

Table 3.1 **Rural electrification in the G5 Sahel: scale, employment and capital cost**

Countries	Average household size (a)	Rural households 2021 (b)	Average electricity consumption (kWh) (c)	Consumption if half rural population served (GWh) (d = b x c / 2 000 000)	Capacity factor (e)	Installed capacity needed (MW) (f = (d x 1000/8760)/e)
Burkina Faso	5.7	2 666 040	454.95	606.46	0.34	206.40
Chad	5.8	2 257 625	454.95	513.56	0.34	174.78
Mali	5.7	355 167	454.95	80.79	0.34	27.50
Mauritania	6.1	1 986 638	454.95	451.92	0.34	153.80
Niger	7.1	2 960 935	454.95	673.55	0.34	229.23
Total	-	10 226 406	-	2 326.28	-	791.72
Cap cost per MW (EUR million)						**9.64**
Total cost (EUR million)						**7 633.87**
Employment	**Employment per MW**					**Total employment**
Employment, installation (per MW)	312.5	-	-	-	-	247 413
Employment, operation and maintenance (O&M) (per MW)	125	-	-	-	-	98 965

Source: Authors' own elaboration based on 2022 data from Demographic and Health Surveys and World Development Indicators and 2019 data from the Green Climate Fund.

3.1.3 What needs to happen to make the change?

Plans for extensive use of solar power can be seen publicly and privately. The AfDB's *Desert to Power programme* (AfDB, 2022a; AfDB, 2022b) sets targets for solar power across 11 Sahelian countries, the G5 countries plus Djibouti, Eritrea, Ethiopia, Nigeria, Senegal and the Sudan. The programme aims to install 3 219 MW of solar capacity across the G5 by 2030 (Table 3.2), four times the capacity outlined above for rural electrification. Further, the programme includes electricity for urban households, industry and services, hence the much larger capacity planned.

Table 3.2 **ADB's Desert to Power roadmap**

Countries	Capacity installed, MW		Potential Electricity output, GWh	
	2025	2030	2025	2030
Burkina Faso	168	819	362	1 765
Chad	189	702	407	1 513
Mali	399	977	860	2 105
Mauritania		335	-	722
Niger		386	-	832
Total	756	3219	1 629	6 937

Source: AfDB. 2022. *Desert to Power Initiative*. Brochure. Abidjan, AfDB

Some of these installations will be run by public utilities, as proposed for the GCF's Mali solar rural electrification project (GCF, 2019) – see Box 3.1.

Box 3.1 Public solar energy for rural Mali

The GCF's Mali solar electrification programme aims to provide solar electricity to 31 000 households (more than 300 000 people, of whom 50 percent will be women-headed households) across 70 communities in 6 rural regions, over 4 years (2019–2023). In all, 4.8 MW of capacity will be installed. The GCF model plans solar plants for a village, with power transmitted on a mini-grid.

Each plant will be operated by a concessionaire responsible for maintenance and upkeep. Daily maintenance will be provided by a trained technician present in the locality, who records voltage, current, frequency, power, hours of operation, abnormal noise, leakage, etc. and inspects distribution lines.

The regional private operator provides "systematic, conditional or corrective maintenance interventions". For "breakdowns, overhauls or major repairs", the operator may call on the supplier if necessary. Meanwhile, local authorities and national energy agencies oversee the quality of the facilities and service to ensure the private operator manages the infrastructure. The price will be set to EUR 0.24/kWh plus a levy of EUR 0.02, making EUR 0.26 per kWh. The project was approved in February 2019 and is expected to be completed by 2025.

Source: Green Climate Fund. 2019. FP102: *Mali solar rural electrification project, Mali.* Banque ouest africaine de développement Decision B.22/07.

Meanwhile, across the Sahel, private companies are at work selling solar installations to households, see Box 3.2. Some, and perhaps most, rural electrification will be driven by firms, as profits are there to be made, while demand is likely to be strong.

Box 3.2 Commercial provision of household solar energy

Alioth System Energy is a private company based in Ouagadougou, Burkina Faso, that sells solar power kits to households across the country, including in rural areas.

As shown in their advertisement below, the 80 W solar panel provided by the Home System can power a television, fan, strip light and light bulbs, torch and rechargeable radio, with possible recharge of mobile phones.

The price is just FCFA 300 000, equivalent to USD 500. This is made all the more affordable by the company's credit scheme, a 10 percent down payment followed by instalments over 2 years, financed by a local bank.

Alioth currently employs 50 staff. Its technicians, who deliver and help install the kits, are, the Director-General reports, are mostly young people, aged 25–30 years.

In some locations, the company uses also subcontractors, thus potentially creating more jobs. The company has around 20 000 customers and Alioth's director general is optimistic for the future of the business: "The need clearly exists."

Source: Interview with Alioth System Energy's Director General.

According to a representative of the Burkina Faso National Electrification Agency, the country has seen major growth in the market for solar energy for residential use. Solar kits of acceptable quality are available from, for example, France and China. It is more and more common to see solar panels on house roofs in affluent neighbourhoods of the capital, Ouagadougou.

It is not just private firms that install rural electrification. For at least the past ten years, rural households in some parts of the Sahel have been able to buy solar panels to install for themselves on their house rooftops, to provide lighting and fulfil other household uses (for Burkina Faso, see Bensch *et al.*, 2018). For example, by 2016, one village just north of Ségou, in Mali, registered no fewer than 172 installed panels (Toulmin, 2020). To the extent that households are prepared to install panels themselves, the requirements for public investment then fall. **The more households install their own solar equipment, the more potential jobs may be created for technicians** who can maintain these installations, repair them when needed and help households upgrade their systems when they have the means to buy more panels.

The main drawback to solar power is that it functions only during daylight hours and preferably with clear skies. Where more continuous electricity is needed, storage will be required. The kits sold in Burkina Faso to households for example include a battery.

Solar power has great potential in the Sahel. In the words of the AfDB (AfDB, 2023):

> The AfDB's *Desert to Power* solar initiative will turn Africa into a renewable energy powerhouse. Desert to Power will stretch across the Sahel region, connecting 250 million people with electricity by tapping into the region's abundant solar resources. Desert to Power will make the Sahel the world's largest solar production zone with up to 10 000 MW of solar generation capacity.

3.2 Irrigation

3.2.1 Why irrigation?

Environmentally speaking, irrigation is part of a green rural transition. It allows farmers to control water, it reduces their dependence on variable rains, and allows them to adapt to a changing climate. By giving farmers more control over water, irrigation increases the productivity of other farm inputs – fertilizer, seed and, above all, human labour. **Economically speaking, irrigation can raise crop production and generate greater returns per ha.**

That said, irrigation, in practice, can be anything but green. Farmers might use irrigation water to clear land for farming, replacing biodiverse habitats with a mono-cropped plot. To try and maximize the returns to their irrigation investment, they may overfertilize the plot, leading to nitrate runoff. They may drench their crops in pesticides, fungicides and herbicides. They may overabstract water, depriving biodiverse ecologies within the catchment of the water on which they depend; if they sink wells, they may deplete aquifers.

Some of these risks may be reduced if irrigation takes place at small scale, with a patchwork of irrigated land across rural areas. "Small scale" may mean more diverse cropping because farmers with small plots may prefer to grow diverse crops to eat or to grow different crops for subsistence and for sale; it may mean sparing use of agrochemicals because smallholders are likely to economize on their working capital.

In any case, irrigation should be promoted in concert with environmentally sustainable and climate-smart agriculture (as Section 3.3 sets out).

3.2.2 What is the current extent of irrigation in the Sahel?

Although most farming in the Sahel is carried out on dryland fields, farmers have also tried to farm with additional water. They have taken advantage of annual floods on the rivers of the Sahel – the Chari, the Niger, Senegal and Volta – planting on the land saturated by flooding. They have used natural depressions where water accumulates, the so-called *bas fonds*, for market gardening. They have built low dams and retaining walls to trap water on their fields. They have sunk wells in valleys where water can be found in the dry season a few metres down.

More formal irrigation was introduced in the twentieth century with some large-scale public irrigation schemes, of which the Office du Niger[7] in Mali, built from 1932 onwards, is the prime example. Using the Markala Dam built across the inland delta of the Niger, this diverts water using gravity to irrigate an area of 100 000 ha. Village schemes have been constructed along the river Senegal since the 1970s, using pumps to take water from the river and farmers have invested in pumps and pipes to extract water from wells and local watercourses.

The *Dakar Declaration on Irrigation* of 2013 classified irrigation in five types as also reported by the *Sahel Irrigation Initiative*: i) rainwater mobilization on farms and on village lands; ii) individual farm irrigation; iii) village schemes, collectively managed and usually of less than 100 ha; iv) large-scale public schemes, usually ranging from 100 ha to 100 000 ha; and, v) irrigation schemes managed by private companies, on areas from 100 ha to several thousand hectares. Of these types, the small-scale irrigation seen in the first three categories predominates in four of the six countries reviewed by the Sahel Irrigation Initiative, except for Mali (where the Office du Niger makes up much of the national irrigated area) and Chad. Small-scale irrigation "accounts for 80 percent of irrigated areas in Mauritania, 65 percent in Burkina Faso and Senegal, 55 percent in the Niger, 25 percent in Mali and 10 percent in Chad" (ibid.).

Only a (very) small part of the farmland of the Sahel is formally irrigated (see Table 3.3). By the late 2010s, some 35.7 million ha were planted to arable crops, of that area just 600 000 ha (1.7 percent) were irrigated, and of these lands, only 287 000 ha (0.8 percent) had irrigation with full control. Even this overstates irrigation: the area actually being watered was in fact 230 000 ha (0.6 percent).

[7] The Office du Niger is semi-autonomous public agency entrusted with developing irrigation over an area of 1 million ha, although only one-tenth of that had been developed by the late 2010s.

Table 3.3 **Irrigation in the G5 Sahel plus Senegal**

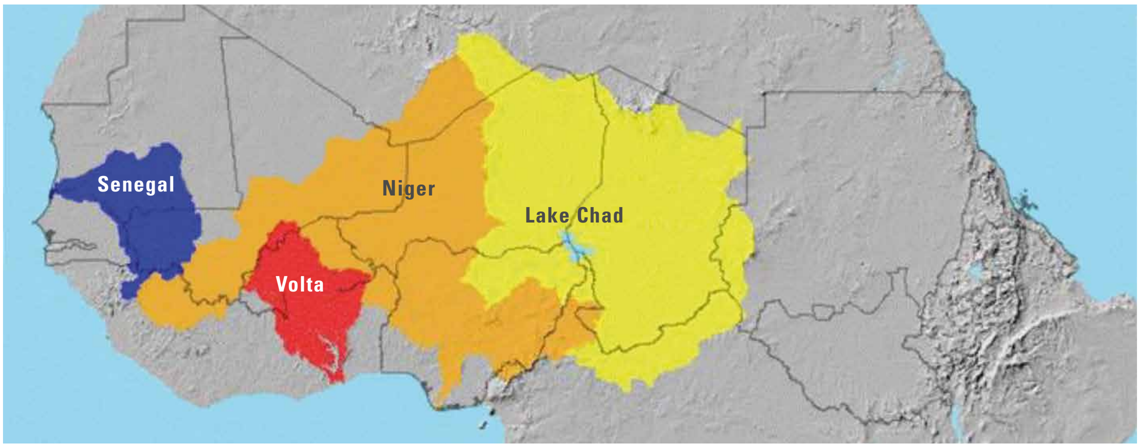
Irrigation in the G5 Sahel plus Senegal	2000/02 ('000 ha)	2017/19 ('000 ha)	Change: 2000/02 to 2017/19
Arable land area,	27 070	35 711	1.32
Area equipped for full control irrigation: actually irrigated	160.0	229.8	1.44
Area equipped for full control irrigation: total	210.3	287.5	1.37
Area equipped for irrigation: total	421.5	602.2	1.43
Irrigation potential	1 586	1 586	1.00
Total population	46 372.4	81 174.4	1.75
Irrigated area, actual to irrigation potential	10%	14%	1.44%

Source: FAO. 2022. *FAO Aquastat database*. Rome. [Cited March 2023]. www.fao.org/aquastat/en

Expansion of irrigation since 2000 has been slow. While the area cultivated has increased by 32 percent since 2000, the one under irrigation has grown by 44 percent. The potential to irrigate is much larger than what is currently watered: estimated at 1 586 000 ha – 7 times larger than the land currently irrigated.

It is a moot point as to how much of the potential can be achieved. This depends partly on water supply. The Sahel has more surface water than might be imagined given the relatively low rainfall, because three of the four great watersheds of the region are fed by waters from more humid lands to the south (see Figure 3.2).

Figure 3.2 **The main watersheds in the Sahel**

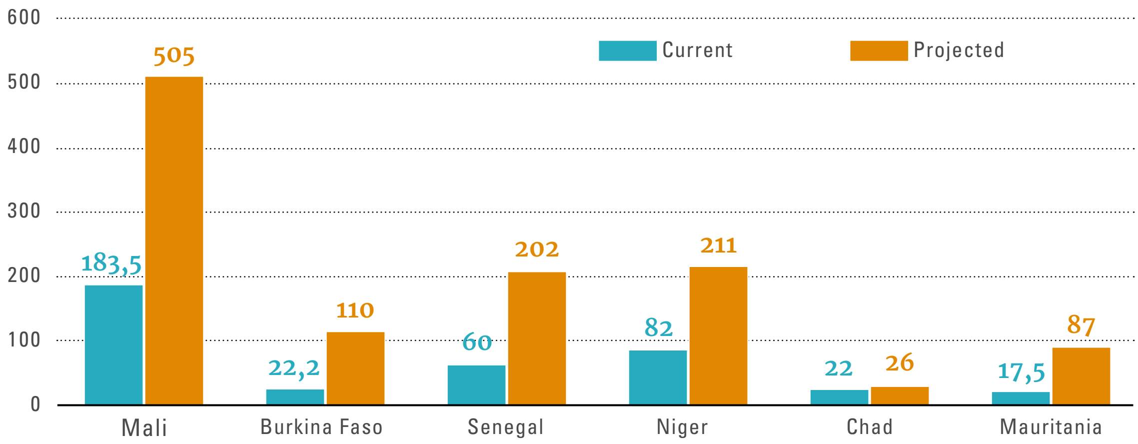


Source: Van der Wijngaart, R., Helming, J., Jacobs, C., Garzon Delvaux, P.A., Hoek, S. & Gomez y Paloma, S. 2019. *Irrigation and irrigated agriculture potential in the Sahel: the case of the Niger river basin. Prospective review of the potential and constraints in a changing climate*. JRC Technical Report. Luxembourg, Publications Office of the European Union.

Groundwater complicates estimates of water supply: not much is known about how much there is. One large aquifer, the Iullemmeden Basin of the Niger, has been recharging for several decades, despite signs of the surface rainfall in its catchment declining (Ousmane *et al.*, 2023). This may be because land clearance for farming can lead to more of the rains seeping down into the aquifer (Favreau *et al.*, 2009).

When, in the mid-2010s, the Sahel Irrigation Initiative (2017) assessed the scope for expansion of irrigation, it set a target of 1 million ha to be irrigated.[8] That, however, included 200 000 ha in Senegal; as such, for the G5 Sahel countries alone, the target was 800 000 ha (Figure 3.3).

Figure 3.3 **Irrigation potential in the Sahel**



Source: Sahel Irrigation Initiative. 2017. ***Strategic Framework for Agricultural Water in the Sahel***. World Bank document [online]. [Cited March 2023] https://documents1.worldbank.org/curated/pt/864771530178541669/pdf/Strategich-Framework-for-Agricultural-Water-Management-in-Sahel-English-version.pdf

3.2.3 What kind of irrigation might be developed?

In setting out its vision for expanded irrigation, the *Sahel Irrigation Initiative* sets "diversity" as one of three pillars:[9]

> Diversity: From Irrigation to Irrigations. The Initiative supports the development of programs that take into account all types of irrigated systems in order to best respond to the needs of producers and to the opportunities presented by each region. Water efficiency is optimized when it is supported by the diversity of compatible irrigation systems within a given region while taking into account the various uses in an integrated approach to managing the resource.

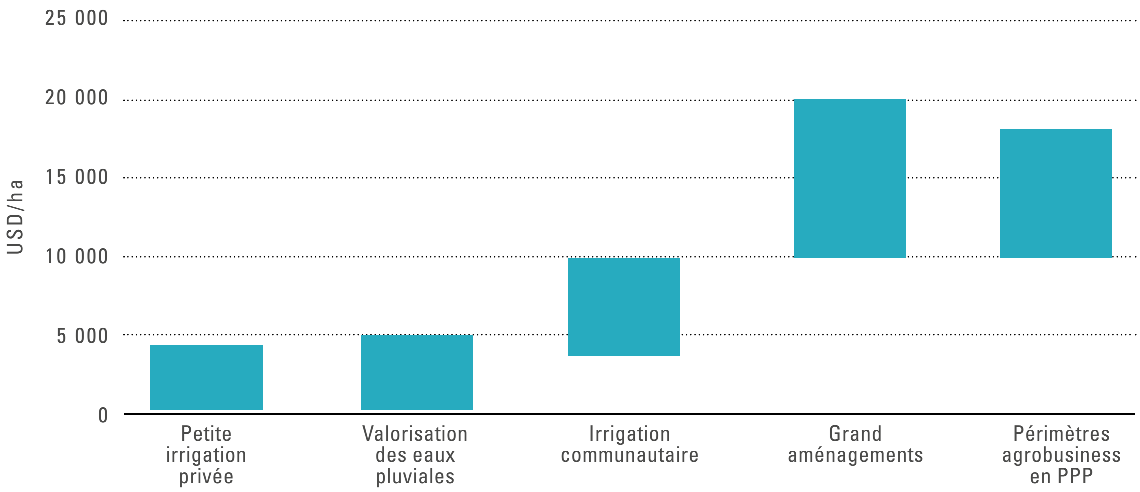
[8] This target was first announced in 2013. At the time it was hoped to hit this by 2020 (Inter-réseaux Développement rural, 2016). A glance at the latest Aquastat data, recorded for 2019, shows actual irrigated area of 230 000 ha for the G5 Sahel, suggesting little has been done to hit the target of 800 000 ha for this part of the Sahel.

[9] The other two are integration (from land development to production system) and commitment (from concertation to commitment by all actors).

Looking at irrigation by scale, the Sahel Irrigation Initiative sees more prospects for developing small-scale irrigation – individual farms and village schemes – than for larger-scale irrigation. Indeed, in the 5 countries, the study's key informant interviews' reports came across just 1 large-scale investment, the irrigation from the Kandadji Dam on the Niger, 180 km upstream from Niamey. The dam is being built first and foremost to generate electricity, but from the reservoir it creates some 45 000 ha are planned to be irrigated by gravity in the medium term – with the potential to irrigation 120 000 ha in the longer run.

Small-scale irrigation has two major advantages over larger schemes. Small-scale systems typically cost less to install (see Figure 3.4), individual farm systems cost well under USD 5 000 per ha, village-level systems cost under USD 10 000 per ha, but large-scale schemes can cost up to USD 20 000 per ha. (Bazin *et al.*, 2017; Sahel Irrigation Initiative, 2017).

Figure 3.4 **Costs to develop irrigation in the Sahel**



Source: Sahel Irrigation Initiative. 2017. ***Strategic Framework for Agricultural Water in the Sahel***. World Bank document [online]. [Cited March 2023] https://documents1.worldbank.org/curated/pt/864771530178541669/pdf/Strategich-Framework-for-Agricultural-Water-Management-in-Sahel-English-version.pdf

Furthermore, small-scale irrigation usually requires less organization to operate than larger schemes (Sahel Irrigation Initiative, 2017, Table 9).

These two advantages are counterintuitive: surely there should be economies of scale in developing schemes of 10 000 ha or larger? This was often thought to be the case in the 1950s and 1960s when, across Africa, governments with donor support invested heavily in large schemes. These typically consisted of a dam across a river, feeding a gravity-flow network of canals, all publicly operated. The promise of transforming agriculture was alluring; the reality unfortunately was disappointing. Often, the works took longer to construct and cost much more than estimated.

The dams created reservoirs that displaced existing farmers and fierce disputes sometimes broke out, which, apart from other harm, delayed the schemes and raised their cost. Often, once they had been constructed, it proved difficult for public agencies to run the schemes and maintain them, partly because the agencies had little incentive to deal with problems swiftly and effectively, and partly because the agencies lacked revenues: public agencies rarely recouped their operating costs from fees on farmers. Finally, farmers did not always use the water they received effectively. Repressed prices for farm outputs in the 1970s meant farmers had little incentive to farm intensively, applying the seeds, fertilizer and labour necessary to make full use of the water (Bazin *et al.*, 2017; Inter Reseaux, 2016; Sahel Irrigation Initiative, 2017; Wiggins and Lankford, 2019).

All these problems could potentially be avoided but to do so it would have required capacity that few public irrigation agencies have demonstrated. Hence the *Dakar Declaration on Irrigation*, in recommending a diversity of irrigations, states that the priority for large-scale schemes is to make the existing schemes function better, rather than to create new ones (Sahel Irrigation Initiative, 2017):

> The *Sahel Irrigation Initiative* promotes the adoption of a scaling-up strategy in which priority is given to the performance of existing systems. Given the financial stakes involved, the States cannot afford to increase the number of irrigated hectares, knowing that other schemes have been abandoned for lack of profitability. Where irrigation develops spontaneously, it must be supported to benefit from good practices that emerged elsewhere. The new developments are designed taking into account achievements and lessons learned from existing developments.

This can work, the reforms to the operation of the Office du Niger in Mali, undertaken since 1982, have been as remarkable as they have been successful. The key change has been to give farmers on the scheme more control over what they can grow and more say in operation and maintenance (O&M), and to allow them to market their produce in search of the best price they can find (Diarra *et al.*, 1999; World Bank, 1999).

Still another advantage applies to small-scale developments. Irrigation needs adapting to local circumstances – water availability, terrain, soils, management of crops, intensity of production, marketing and the value of the intended crop. These are matters better addressed by individual farmers who know their conditions, rather than through the centralized planning of a public agency. "Small scale" also means that mistakes, and their costs, can be contained and remedied. Leastways, if the investment fails, then the cost does not become a burden to the state.

Mistakes are quite common with irrigation when schemes are designed by the state, or any other outside agency, including well-meaning non-governmental organizations (NGOs) (see Box 3.3). In the 1970s, the Senegalese public agency *Société d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et de la vallée de Falame (SAED)*, constructed irrigation perimeters along the river Senegal to allow villagers to irrigate in the dry season – but the villagers ran the pumps only during the wet season. This was because most of the men in the villages departed for seasonal jobs in Dakar and other towns during the off-season: they had better things to do than stay in the village and irrigate a dry season crop (Diemer, Fall and Huibers, 1991; Niasse, 1990, 1992; Woodhouse and Ndiaye, 1991).[10]

Box 3.3 NGOs missing the point: irrigation in Réo, Burkina Faso

In the city of Réo in Burkina Faso, in the late 2010s many farmers had small plots, averaging 0.6 ha, to grow onion, tomato, cabbage, garlic, etc., watering them from shallow wells.

Two NGOs worked in the area, convinced they had solutions to what they considered were farmers' problems.

One NGO demonstrated drip irrigation, convinced that farmers needed to save water. The kits proved costly and hard to maintain and none of the farmers used them as in general, they were not short of water, they were short of land.

The other NGO promoted agroecology and taught farmers how to farm ecologically, with fewer input costs but more labour. Farmers went to the schools but few adopted all, if any, of the practices. The techniques proved time- and skill-consuming, and inputs for agroecology, above all manure, were not so easy to collect from free roaming livestock.

Eventually, the key problem for farmers was the lack of capital and neither NGO addressed this.

Source: Gross, B. & Jaubert, R. 2019. *Vegetable gardening in Burkina Faso: drip irrigation, agroecological farming and the diversity of smallholders.* Water Alternatives.

Technical advances also favour small-scale irrigation, in the 2010s, the falling cost of photovoltaic cells meant that solar-power pumps became increasingly economical. They can be used for the limited lift operations of farmers abstracting from a stream, pond or shallow well (See Box 3.4).

[10] Circumstances change. After the disappointments experienced in the 1970s and 1980s, things improved. By 2010, good yields of rice, 5–6 tonnes per ha, had been seen in the valley (Larson *et al.*, 2010).

Box 3.4 The promise of solar pumps

By the 2010s, the cost of photovoltaic panels to generate electricity from sunshine had fallen to the point where solar-powered pumps had become competitive with diesel pumps.

The initial costs are greater than those for diesel pumps but, once installed, a solar pump costs very little to run. Meanwhile, with many fewer moving parts, solar pumps require less maintenance and can last much longer than diesel pumps, the panels for example, can last 25 years.

In 2017, the World Bank calculated that, over the life cycles of diesel versus solar pumps, the latter were running at half the cost of the former.

Solar pumps are being adopted but perhaps not as quickly as they might; their adoption is hindered by their higher initial capital cost, lack of familiarity with the technology and the danger of the solar panels being stolen if not guarded.

Source: Hartung, H. & Pluschke, L. 2018. *The benefits and risks of solar-powered irrigation a global overview.* Rome, FAO & GIZ.

3.2.4 What is the potential to create new jobs?

If only 14 percent of the area that could be irrigated in the G5 Sahel is being irrigated (Sahel Irrigation Initiative, 2017), then large expansions are possible. The Dakar Declaration on Irrigation aimed for 800 000 ha being irrigated by 2020 in the 5 countries, but by 2019, only 230 000 ha were irrigated. This suggests that, over the medium term, during the 2020s, the potential remains to extend irrigation to another 570 000 ha.

If irrigation were so expanded, how many more jobs might be created? This depends on how the irrigated fields are used. Some crops require more labour than others. Meanwhile, if fields can be cropped twice a year, much more employment is created compared with on dryland fields. When irrigation is used to grow high-value crops such as fruit and vegetables, these require considerable labour to irrigate, to weed, to protect crops against pests and disease (whether by applying agrochemicals or adopting ecological defences) and to harvest and pack produce, for example fruit and vegetables require more care and tasks are time-consuming as they need to be handled to avoid any damage). In the city of Réo in Burkina Faso, for example, farmers in the mid-2010s were deploying and employing the equivalent of four or five full-time workers per ha (Gross and Jaubert, 2019). Namara *et al.* (2011) show that small-scale irrigators in northern Ghana were using between 230 and 700 days of labour per ha. To estimate, somewhat broadly, the potential to create jobs, an average of two more full-time equivalent jobs per ha has been assumed.

On that basis, if another 570 000 ha were to be irrigated, 1.14 million jobs could be generated on the fields alone – not counting extra jobs in providing inputs and services to irrigators, and in collecting, processing and transporting extra produce – and not further counting the additional jobs in the rural economy that may arise when farmers spend additional income. Such multipliers will be discussed in section 3.7.

3.2.5 What jobs would be created?

Most of the jobs foreseen here are jobs in the fields: planting, watering, weeding, harvesting and packing. Skills for these jobs can be learned by doing, if those working need any guidance at all – because most will already know farm work.

There will also be jobs servicing the irrigation equipment. Even if solar pumps need less maintenance than diesel pumps do, they will still need some attention. One might imagine that, for every 200 ha under small-scale irrigation, there will be a job for a technician who knows how the equipment works, who obtains spares and who visits the farmers to maintain equipment and to repair breakages.

In the scale of expansion imagined, 570 000 ha, this would be 5 technicians for every 1 000 ha, so 2 850 jobs in all. Those technicians need training, or possibly can be apprenticed to more experienced mechanics.

3.2.6 What needs to happen to make this change?

To develop irrigation, farmers need capital to buy equipment and guidance on how best to use their irrigation. The state needs to provide complementary public goods, above all roads to markets and extensionists to work with farmers. The state should also have some plan to guide use of water in the catchment or aquifer, perhaps in concert with local government and community groups. More formal requirements apply for schemes at scales larger than the farm, where public investments in works and equipment may be needed and where due attention to how the scheme will be operated and maintained must be paid (Inter-réseaux développement rural, 2016; Sahel Initiative for Irrigation, 2017). This section focuses on two of the more important of these conditions: capital and rational water use.

Capital. The cost of small-scale irrigation falls first and foremost on farmers, mainly in terms of digging wells or erecting diversion structures in water courses and excavating furrows, and buying pumps and pipes. At present, most small-scale irrigation sees farmers individually or in groups working by hand to dig and shape physical structures but paying private providers for equipment like pumps and pipes. Cash payments may amount to USD 5 000 per ha.

If all of the expansion contemplated – 570 000 ha – were carried out by individual farmers, the capital cost would be USD 2.85 billion. Costs will probably be higher, depending on the fraction that is developed by village or larger-scale schemes, whose unit costs of development are typically higher.

Farmers currently almost always pay for any cash costs of irrigation by drawing on savings, earnings from second jobs or remittances. This means that only the better-off can afford to do this.

To widen access to irrigation, some form of credit will be needed. Options include banks or microfinance institutions offering dedicated lines of credit for irrigation, perhaps backed by some public guarantee to limit losses to any non-performing loans. Added to this are the challenges that face bankers when dealing with farmers: how they can be sure the farmer is both competent – hence the investment will generate returns to repay the loans – and trustworthy, and will repay. The usual banking response is to register some asset as collateral that will be forfeited if the loan is not repaid. Equally, the usual problem is that most farmers have no such assets: land, for example, is often a collective asset that cannot be pledged.

An alternative is for suppliers to lease out equipment to farmers, and to recoup the cost in instalments. This has the advantage that the kit leased out becomes the security, to be recovered if the farmers default. Leasing is a simple and transparent transaction, whereby both the supplier and the farmer can readily understand the deal, including both the business and the moral dimensions. It does require, however, that suppliers as leasers have the capital to offer the package. This capital might be obtained from a bank: it is far easier for commercial banks to deal with half a dozen equipment dealers, with credits counted in the hundreds of thousands of dollars, than to offer small loans of up to USD 5 000 to several thousand farmers.

Rational water use. The ambition to expand current irrigated areas by more than two times, to get irrigation up to more than half the total potential, risks in some areas an overdrawing on surface or groundwater. Not only does overabstraction threaten the irrigation itself but also further ecological harm may ensue within the catchment.

Making sure this does not happen is not however straightforward. A planner, operating at catchment level, would need to know just how much water was being abstracted within the catchment, and preferably where, and just how much water was available for sustainable abstraction from both surface water and aquifers. The data demands for this are daunting. Who is going to measure water use by what may be, at catchment level, several thousand farmers? Who can estimate water supplies, above all those in the aquifers?

Entrusting this to scientific assessment by specialists employed by some catchment authority or ministry of water is fanciful as the costs of employing specialists and carrying out detailed measurements are high, while public funds are usually limited.

Hence a way has to be found to generate information by simpler means. Sentinel sites may be one answer. For surface water, identify points in the catchment watercourses where flows can be monitored in order to capture changes. For groundwater, select a sample of wells where the depth to water can be measured. Install simple measuring tools – a marked stake inserted into a watercourse showing river height, a measuring chain for a well – and ask local people to submit monthly reports by text message. Reward them for this with airtime while running occasional supervisory checks on the measurements submitted.

Use the resulting information to inform central authorities, any catchment body and more local groups. Where irrigation is flourishing and water management may become problematical, form local bodies to assess information and decide how to respond.

This is fraught with difficulty and dangers. Once irrigators have become accustomed to drawing the water they need, they will not take kindly to any evidence that shows they need to scale back their withdrawals – even if it threatens their own interests in the future. When overdrawing becomes an issue across a catchment, expect that individual farmers or communities of farmers will blame others, but not themselves, for overuse. Nevertheless, the effort should be made: to give the power to take action to limit withdrawals as close to the irrigators as possible. Farmers may resent being told to economize but it will be easier to accept if the message comes from other (local) farmers, rather than, say, a committee of scientific specialists based in a distant capital

3.3 Environmentally sustainable and climate-smart agriculture

3.3.1 Why environmentally sustainable and climate-smart agriculture[11]

Crop farming in the Sahel, in common with cropping in many other parts of the world, is not environmentally sustainable. Some fields are being eroded, losing topsoil and nutrients. Some plots, even if only a small share of the cropped area, are excessively fertilized, with runoff of nitrates into water systems. Some crops, especially those of high value, are sprayed with pesticides applied excessively or carelessly, leading to toxins entering the air, soil or water, posing dangers to humans and other living things. The expansion of the cropped area – up by 32 percent since 2000 across the G5 Sahel countries (FAOSTAT, 2022) can lead to loss of valuable ecosystems, including forests and wetlands, reducing biodiversity and imperilling ecosystem functions. There may also be effects on local and regional climate.

Where such problems arise, they need correction, so as to create farming systems that do not degrade the soil; pollute air, soil or water; or clear habitats rich in biodiversity and essential to the overall functioning of ecologies and climate.

At the same time, global heating is leading to climate change. The broad outlines of this change are clear, although the precise effects likely in specific places are slightly harder to predict. For the Western Africa Sahel, probable outcomes include higher temperatures, to the point where crops will cease to grow during hot spells and people will no longer be able to work actively, and more rainfall, but with increased variability of rains, less certainty of when they will begin and end, and increased frequency of storms (Holmes *et al.*, 2022). Farmers and pastoralists will have to adapt to these changes. If possible, they should also reduce emissions of greenhouse gases, even if their emissions are very low compared with emissions from farms in other parts of the world and compared with emissions from other economic sectors.

3.3.2 What measures are needed?

Behind the broad changes outlined lie the details of the changes needed (Box 3.5). The list of potential actions is long but not all are needed in every field, on every

[11] These terms describe actions that form part of nature-based solutions (IPCC, 2022). The actions are either the same as, or very similar to, those of regenerative agriculture (Ewer *et al.*, 2023). Many of the actions proposed are forms of agroecology.

farm: this is a menu of actions to be adapted to local, indeed to field, characteristics. Some actions serve more than one purpose, hence are repeated in the agenda.

Box 3.5 Actions to make agriculture environmentally sustainable and climate-smart

Soil conservation and management:

- prevent soil erosion and degradation;
- increase organic matter in soils; and
- promote water infiltration.

Land conversion to cropping:

- reduce and prevent conversion of valued habitats to fields and pastures with loss of ecosystem functions and biodiversity.

Manage agriculture for biodiversity:

- encourage farming diverse in crops and varieties, animals and breeds; and
- set aside fractions of farmland (up to 20 percent) for wildlife: establish field margins, hedgerows, coppices, trees on fields.

Prevent pollution from crop farming and livestock:

- apply fertilizer and agrochemicals sparingly, if at all;
- use integrated pest management to reduce or avoid use of agrochemicals;
- do not burn stubble and other wastes; and
- incorporate animal manure into soil.

Economize on water for farming:

- use irrigation water sparingly to avoid overabstraction from catchments and aquifers;
- line canals to prevent water loss;
- use sprinklers and drip tubes to economize on water application; and
- adapt agriculture to climate change.

Adapt farming to new patterns of weather, pests and disease:

- switch to crop varieties or livestock breeds that better fit the weather, and that resist new pests and diseases, and breed such varieties if not already known;
- irrigate to combat reduced rains in areas with water supplies – some irrigation may no longer be possible for lack of surface or ground water;
- diversify farming to reduce vulnerability – agroforestry may apply in some cases - and diversify from farming;
- reduce costs and increase returns to make farming more viable; and
- in some cases, relocate productive farming from areas that lose potential under new climates.

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Increase resilience of farming to extreme weather:

- improve weather forecasting and get information to farmers so they can plan better for shocks;
- (as above) grow varieties that can tolerate heat, dry spells, hail and high winds, and breed varieties to cope if not already available;
- develop cropping systems that conserve moisture and build soil structure to withstand droughts better – agroforestry is one example; and
- irrigate to provide more control over water.

In low-lying coastal areas:

- invest in dykes to protect against rising sea levels;
- grow crops resistant to salinity and flooding; and
- mitigate agriculture's emission of greenhouse gases.

Livestock - reduce methane emissions:

- improve feed production/pasture management to reduce methane per head;
- prevent conversion of forests, peatlands and other wetlands to arable and grazing;
- reduce release of nitrous oxides from fertilizer;
- apply fertilizer more economically and efficiently; and
- reduce flooding of paddy fields, through less frequent wetting and draining of fields.

Carbon capture:

- encourage farming systems that capture carbon, for example through agroforestry or no-plough systems.

Sources: FAO. 2015. *Agroecology for food security and nutrition*. Rome, FAO.

Of the above list, the priorities for the G5 Sahel countries are soil and water conservation and soil fertility management. Conservation of soil and water is the cornerstone of environmentally sustainable agriculture: there is little point in working to maintain or augment soil fertility if soil is not conserved and water is squandered.

3.3.3 Experiences of soil and water conservation in the Sahel

The rural environment of the Sahel is potentially threatened by population increase, often as high as 3 percent a year over the past half century or so (United Nations Population Division, 2022). This has led to the conversion of more and more woodland, bush and pasture into fields. Fields that in the past would have seen fallows used to restore soil fertility are now cropped every season. Fields have taken over pastures, reducing the land available to pastoralists.

In the 1970s, some commentators created a naïve narrative around these facts, one in which ever-greater human pressure on natural resources led to their degradation, thereby forcing people to work their resources even harder and creating a downward spiral of environmental degradation and poverty (as documented by Cloudsley-Thompson, 1977; Franke and Chasin, 1980; Morse, 1987). Some even argued that resource degradation would desiccate local climates and so reinforce the downward spiral. It was easy to imagine such processes when the great drought of 1968–1973 hit the Sahel, when not only harvests were lost but also many livestock perished, leaving people impoverished and destitute (Sinclair and Fryxell, 1985).

Subsequently, it has become clear that the narrative oversimplified, that some processes hypothesized were simply incorrect (ideas about desiccation among them). Above all, evidence of a downward spiral was lacking when like was compared with like. Comparing the Sahel during the droughts of the 1970s and 1980s to the Sahel in a more humid time – the 1950s and 1960s – was always likely to produce the appearance of a trend towards degradation, one that was much less apparent when landscapes were compared between times of similar rainfall.

Detailed study of vegetation across much of the Sahel shows not degradation but rather a greening of the Sahel (Olsson, Eklundh and Ardö, 2005). If so, what has made the difference? Much of the answer comes from farmer actions. **Some former narratives saw farmers as passive victims of ecological processes. And yet evidence shows that many Sahelian farmers have been proactive since the early 1980s in conserving and enhancing their natural resources.**

Farmers have worked out how to conserve soil and water on their fields. They have variously built low stone walls across contour lines and excavated low levees in half-moons (demi-lunes) to retain water and soil. They have dug small pits (zai) on their fields to concentrate organic matter and water, to which they add manure and fertilizer before sowing seed into them. They have grown trees on their farms to provide shade; to hold the soil; to recycle nutrients; and to provide fodder, firewood and fruits. Many of these measures have been developed locally in the Sahel; their spread – to which we turn in a moment – constitutes a remarkable story of indigenous innovation, and of agricultural progress. It is a story very largely created in the Sahel, about which outsiders often know too little (Cotillon, Tappan and Reij, 2021; Magrath, 2020).

How far has indigenous soil and water conservation spread? In Burkina Faso, 10 percent or more of the land has been treated (Nyamekye *et al.*, 2018) and an analysis of results from other peer-reviewed publications showed that zais cover a total land area of 30 000 to 60 000 ha in northwestern Burkina Faso and more than 200 000 ha of agricultural land in central Burkina Faso. The adoption rate of zais in

Yatenga province [also NW Burkina Faso] was between 49 percent and 60 percent. Nyamekye *et al.* also record stone bunds covering more than 11 percent of the land in Centre-North and more than 5 percent of the land in Centre-West of Burkina Faso.

For Burkina Faso and the Niger, Magrath (2020) reports 6 million ha as having been treated with some form of conservation. For southern Niger, Reij and Winterbottom (2015) describe agroforestry adoption thus in the regions of Maradi, Zinder, and across southern Niger, over 5 million ha have been regreened. They observed similar changes in Mali where on-farm tree densities have dramatically increased over the past decade on 500 000 ha of Mali's Seno Plain.[12]

Coverage, while substantial, is far from complete, for example, an estimate of 6 million ha treated in the Niger can be compared with 17 million ha of arable land for the whole country. For Burkina Faso, estimates that reach almost 700 000 ha in 2 regions can be compared with 6 million ha of arable land across the country. For Mali, the 500 000 ha of fields with more trees can be compared to 6.4 million ha of arable land nationally (FAOSTAT, 2022).

The benefits of these measures can be seen first and foremost in higher crop yields from treated land. For example, surveys in the Niger show that integrated soil fertility management (ISFM) can raise yields of cereals and pulses substantially (Table 3.4), with yield gains of 50–100 percent comparing ISFM with no inputs and of 25–50 percent more comparing ISFM with use of fertilizer alone. These increases over large areas mount up: Reij estimates that agroforestry has allowed the Niger to produce 600 000 tonnes more of cereals a year.[13]

Although ISFM raises crop yields, average yields remain low (Table 3.4, last four rows) – at too little to keep up with the Niger's population growth. ISFM practice, which includes agroforestry, can be considered a foundation for higher yields: if mineral fertilizers are then applied, even in small quantities, considerable extra yield can be gained (Chris Reij, 2023).[14]

Undertaking soil and water conservation costs time and effort, so the benefits need to be set against these costs. In the Niger, costs of conservation by farmers have been estimated to average USD 20 per ha (Reij and Winterbottom, 2015). The

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[12] To this may be added some 6 million ha of old agroforestry parkland dominated by néré and karité, some of which is being rejuvenated (Chris Reij, 2023).

[13] This estimate is based on 6 million ha times an average increase of 100 kg/ha. Research shows increases vary from 30 kg to 350 kg/ha depending on tree densities and tree species (Chris Reij, 2023).

[14] This may seem to contradict the principles of environmental sustainability, but this is not necessarily the case: small additions of key nutrients imported from elsewhere can be sustained. It has long been established that some soils of the Sahel lack minerals for crops (van Keulen and Breman, 1990).

Table 3.4 **Adoption rate of soil fertility management practices for major crops in the Niger**

Crop	ISFM	Fertilizer only	Organic only	No inputs
	Percentage of plots with sustainable land management practice (A)			
Millet (n = 2 174)	9.4	8.0	72.0	10.6
Groundnuts (n = 459)	14.4	7.2	72.0	6.4
Sorghum (n = 1 253)	11.1	6.5	72.0	10.4
Cowpea (n = 1 121)	12.3	9.3	72.0	6.4
All crops	8.9	9.3	33.7	8.5
	Mean yields (kg/ha)			
Millet	521	423	477	340
Groundnuts	907	697	349	525
Sorghum	515	349	411	348
Cowpea	565	205	300	259

(A) Includes: manure, crop rotation, agroforestry.

Source: Nkonya *et al*. 2016. *Economics of land degradation and improvement. A global assessment for sustainable development*. Washington DC, IFPRI.

same authors state that the returns in the Niger to regreening have been worth USD 500 million in all, while, over 20 years, they calculate the investment costs in Maradi and Zinder at under USD 100 million – indicating a possible 5:1 benefit–cost ratio.[15]

These benefits may even undercount what has been achieved in two respects. First, they measure yields of comparable plots with different treatments. But, if the untreated plots are being eroded, if their soil is being depleted, then future yields will, all other things being equal, decline. Benefits over the medium term should be set against the costs of future degeneration. For the Niger, Nkonya *et al.* (2016) estimate the losses to land use changes that degrade resources, as follows, cost of land degradation due to land-use and land-cover change (LUCC) is about 2007 USD 0.75 billion, which is 11 percent of the 2007 GDP of USD 6.773 billion and

[15] They report their source as follows: "Data from Place *et al*. 2013 and Pye-Smith 2013 show that the economic benefits of regreening range from USD 200–USD 1000 per household. Farm size for rural households in the Niger is about 4 ha, where 5 million ha have been regreened. Using a conservative estimate of USD 100/ha in economic benefits, this amounts to USD 500 million in annual benefits for rural households."

1 percent of the 2001 value of ecosystem services in the Niger. Further, the cost of action to address land degradation is USD 5 billion while the cost of inaction is about USD 30 billion over the 30 year planning horizon. As expected the returns for taking action are quite high. Every US dollar invested in taking action returns about USD 6, a level that is quite attractive. If these saved costs are added to the gains, then the benefit–cost ratios sum to more than 10:1: enormous returns.

Second, another gain not usually counted is that of capturing carbon in conserved landscapes, as reported by Reij and Winterbottom (2015), the 5 million ha of farmer-managed regreening in the Niger has sequestered about 25–30 million metric tonnes of carbon over the past 30 years (Stevens *et al.* 2014).

The value of carbon captured has been estimated at from USD 20 a tonne upwards to USD 50 a tonne, with the International Monetary Fund (IMF) in 2019 arguing that emissions should be taxed at USD 75 a tonne. The 25 million tonnes of carbon captured by agroforestry in the Niger might therefore be valued at between USD 500 million and USD 1 875 million. These values alone would cover investment costs.

3.3.4 What is the potential to create new jobs?

For employment, much depends on the area that might, over the medium term, be treated – and, above all, with the measures used to conserve soil and water.

Some 35 million ha of the G5 Sahel countries are estimated to be under arable crops. Not all this land necessarily needs attention. Some will be, by topography, soil and local climate, less vulnerable to degradation; some will be under crops that protect the soil by their cover; some will be well managed by farmers; and some – we have already mentioned estimates of up to 6 million ha in southern Niger – has already been treated. Quantifying the scope to apply such measures to untreated fields that need protection is thus at best an educated guess. This broad estimate might span the range from a quarter to one-third of the current arable area.

How much employment these measures create depends greatly on which techniques are used, and the topography and soil conditions on which they are undertaken. To obtain a broad estimate, assume that all the land to be treated needs either stone lines or semi-circles (demi-lunes) and half of this land will be pitted with planting pits (zai). Estimates of the days taken to construct stone lines (cordon pierreux) across fields are around 30–60 days per ha depending on the availability of stones and on the means of transport used: to create semi-circles may be 30–80 days per ha depending on how hard the soil is; to dig out pits may take up to 100 days per ha. Annual maintenance of these, per ha, may be 10 days for the pits, 5 days for the semi-circles and 2 days for the stone lines (Table 3.5).

Table 3.5 **Potential extra jobs in soil and water conservation**

Total arable area ('000 ha): 35 711	Labour per hectare, days (a)	Share of land treated by specific measures (b)	Share of arable treated (c)	Total area treated ('000 ha) (d = b x c x 35 711)	Days of labour ('000s) (e = a x d)	Full-time job equivalents ('000s) (f = e/200)
Area treated: **A = one-quarter all arable** Construct:						
Stone lines	45	0.5	0.25	4 463.88	200 874.38	1 004.37
Semi-circles	55	0.5	0.25	4 463.88	245 513.13	1 227.57
Zai pits	100	0.5	0.25	4 463.88	446 387.50	2 231.94
Total						**4 463.88**
Maintain						
Stone lines	2	0.5	0.25	4 463.88	8 927.75	44.64
Semi-circles	5	0.5	0.25	4 463.88	22 319.38	111.60
Zai pits	10	0.5	0.25	4 463.88	44 638.75	223.19
Total						**379.43**
Construct: **Area treated:** **B = one-third all arable**						
Stone lines	45	0.5	0.33	5 892.32	265 154.18	1 325.77
Semi-circles	55	0.5	0.33	5 892.32	324 077.33	1 620.39
Zai pits	100	0.5	0.33	5 892.32	589 231.50	2 946.16
Total						**5 892.32**
Maintain						
Stone lines	2	0.5	0.33	5 892.32	11 784.63	58.92
Semi-circles	5	0.5	0.33	5 892.32	29 461.58	147.31
Zai pits	10	0.5	0.33	5 892.32	58 923.15	294.62
Total						**736.54**

Source: Author's compilation. Estimates of labour time taken from case studies in the Sahel logged in the WOCAT database of sustainable land management, and further exchanges with C. Reij from the World Resources Institute.

Making these broad assumptions suggests labour needs of 4.5–5.9 million full-time equivalent jobs for construction, and 380 000 to 737 000 jobs in annual maintenance. Much depends, however, on the assumptions made and, above all, on the area where zai pits are dug. The pits are no doubt effective but constructing them is back-breaking work when done by hand with a pick. If ever a task called out for mechanization, it is digging these pits.

Almost all the employment generated by a drive for environmentally sustainable agriculture arises on fields: much of it is manual labour. This is arduous work, usually paid at the low wages that apply for unskilled labour in rural areas. It might be made more attractive for youth if operations were mechanized – although this would of course reduce the volume of employment, with small groups of youth operating machinery acquired on leases from suppliers. It might be made more attractive if public goods created were paid for – see below for a discussion on rewarding farmers for capturing carbon.

Some jobs can be created for extensionists – that is, field advisers trained in the skills of conservation and agroecology, who can guide farmers on appropriate practices for their fields. These will not necessarily be new jobs, because some extensionists are already at work, paid for by governments, NGOs and, sometimes, for cash crops, by companies that buy the produce. Given the scale of effort that should be made, many more extensionists will be needed. If there were, for example, one additional adviser for every 5 000 ha of arable land, this would require another 6 000 or more advisers across the G5 Sahel.

Some other practices that are environmentally sustainable for agriculture do not necessarily involve more labour. For example, switching varieties of crops to those more resilient to climate stress does not increase time spent on farming. Moving from applying agrochemicals to integrated pest management changes the work done – from spraying to planting insect predator refuges, monitoring and so on – but does not necessarily increase the time spent farming. Apart from soil and water conservation, only irrigation demands more time, and that has been covered in the previous section.

3.3.5 What needs to happen to make this change?

If farmers are to adopt environmentally sustainable and climate-smart agriculture, they will need more knowledge, from three main sources:

- Formal public research and public extension.
- Formal private research and dissemination of ideas by suppliers of seed, fertilizer, chemicals, vet drugs, tools and machinery.

- Development partners.
- Informal learning from trials and pilots – perhaps run by farmer field school or junior farmer field schools – that can then be disseminated through pamphlets, radio, YouTube, text messages and so on.

Not all knowledge will be immediately applicable on farm, some will need tailoring to individual farms, fields, herds and flocks. **Farmers thus need education – literacy, numeracy, basic agronomy and biology: educated farmers will find it easier to tailor principles to their circumstances.**

The skills farmers need to change their practices range from the straightforward, for example, changing from one crop variety to another, learning about contour ploughing, to more complicated matters as integrated pest management. The latter will require training of farmers, but most measures are relatively straightforward, once explained and demonstrated. Farmers can, moreover, imitate what they see on the fields of their neighbours, and adapt practices to their fields.

Once farmers have the knowledge and skills, they need little more incentive to apply many environmentally sustainable and climate-smart practices, because they will reap the rewards – in lower costs, higher yields and fewer losses to disasters.

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Most practices involve little cash investment, with the notable exceptions of irrigation works and equipment, dealt with in the previous section. In most other cases, the investment is small, a change of seed, for example. Indeed, several practices save on costs, such as more sparing use of chemicals.

Some environmentally sustainable farming confers benefits on other people – more positive externalities, fewer negative externalities – and generates public goods. Some of these measures allow ecosystems, the very basis of life, to function to the benefit of all humanity. Most farmers, however, will take up practices whose benefits arise beyond their farm only if they are rewarded for the benefits they provide to others (or for reducing costs to others).

The prime example of external benefits lies with the capturing of carbon in trees, soil and farming systems. Already markets for carbon exist, although not for agriculture in the G5 Sahel. A demand exists from firms and households in high-income countries to buy carbon offsets. In an ideal world, these countries would pay farmers in the Sahel to lock carbon into their farming systems. The obstacles to making this happen, however, are formidable, in monitoring, verifying and reporting on who has captured how much carbon and where (Vermeulen *et al.*, 2019). It may take some time to overcome these obstacles but in the medium term, say by 2025, it should be possible to start pilots, and by 2030 to start to roll out generalized schemes to reward farmers who capture carbon.

3.4 Restoration of the rural landscape

This axis of green transition resembles and overlaps the previous one, of environmentally sustainable agriculture. The difference is that, while the previous section concerns making fields, individually farmed, sustainable, much of this section is about restoring the commons: the grazing, forest and wetlands of the G5 Sahel.

3.4.1 Why restore and regenerate landscapes?

Landscapes in the Sahel have changed substantially over the past century, as people have converted forest, woodland and wetland to fields for crops and for pasture for grazing and to build settlements. For the whole of the Sahel – the G5 Sahel plus Djibouti, Eritrea, Ethiopia, Nigeria, the Sudan and Senegal – between 2001 and 2018, an estimated 5.1 million ha of forest and shrubland were lost (27 percent of the previous area to forest and shrub), while 13.1 million ha of grassland were added (Table 3.6). Areas to crops, however, did not change for the whole Sahel region, although the G5 Sahel did see an increase in the area under crops (Mirzabaev *et al.*, 2022).

Table 3.6 **Land use and land cover transitions Sahel, 2001–2018**[16]

Land use and land cover in 2001 ('000 ha)	Land use and land cover: 2018 ('000 ha)									
	Forest	Shrubland	Woodland	Grassland	Wetland	Cropland	Settlements	Barren lands	Water bodies	Total
Forest	4 607	1	778	1 394	87	98	4	-	-	6 969
Shrubland	6	17 783	3	7 631	3	11	3	380	-	25 819
Woodland	173	-	1 725	434	5	190	5	-	-	2 531
Grassland	1 392	2 535	845	365 000	228	16 710	111	1 914	20	388 755
Wetland	33	-	3	186	1 636	10	6	4	8	1 887
Cropland	105	2	115	17 384	12	67 268	149	7	-	85 041
Settlements	-	-	-	-	-	-	1 255	-	-	1 255
Barren lands	-	1 017	-	9 853	47	4	5	465 000	38	475 965
Water bodies	-	-	-	4	32	-	-	37	1 415	1 489
Total	6 315	21 338	3 469	401 887	2 050	84 292	1 537	467 343	1 481	-
Net gain/ loss	-654	-4 481	937	13 132	163	-750	282	-8 622	-8	-
Percentage change	-9.4	-17.4	37.0	3.4	8.6	-0.9	22.5	-1.8	-0.5	-

Source: Authors' own elaboration based on Mirzabaev, A., Sacande, M., Motlagh, F., Shyrokaya, A. & Martucci, A. 2022. *Economic efficiency and targeting of the African Great Green Wall*. Nature Sustainability.

[16] In the Table 3.6, Sahel refers to G5 Sahel countries plus Djibouti, Eritrea, Ethiopia, Nigeria, the Sudan and Senegal.

Forests are defined as woody vegetation with height >2 m and covering at least 60 percent of land area. Woodland as with tree cover of 30–60 percent (canopy >2 m) and shrubland as dominated by woody perennials (1–2 m height) >10 percent cover.

Despite high resolution of pixel size (25 ha), the underlying database underrepresents croplands because it does not include fallowed land under the cropland category, and also small farm sizes across the Sahel and frequent interspersion of cropped areas within other biomes could lead to a lower extent of cropland areas represented.

While no-one disputes changes to landscapes, debates continue over the net effect on vegetation cover – is the Sahel desertifying, becoming browner, or is it perhaps becoming greener? On the causes of change – to what extent are changes driven by farmers and herders, or by climate change and natural ecological processes (Rasmussen *et al.*, 2015)? Although it is commonplace to read of widespread land degradation in the Sahel, other studies show a net increase in vegetation over the medium term. While it is equally often said that it is local people changing the landscape, other studies show a stronger role for climate change. For example, Burrell *et al.* (2020) draw maps of the G5 Sahel countries that show net increases in vegetation from 1982 to 2015 for much of the region, driven primarily by variations in climate and by increased concentrations of carbon dioxide (which promote plant growth) in the atmosphere.

While these debates continue, fuelled in part by increasingly precise remote-sensing, two things are more certain. First, at local level some lands have been degraded, as cover of trees and shrubs has been lost, with some crop fields having been overworked, leading to loss of soil and nutrients (Cotillon, Tappan and Reij, 2021).

Second, governments in the Sahel, and the international bodies that support them, recognize land degradation to be serious and have resolved to remedy it. Three major international initiatives that apply to the Sahel stand out (Reij *et al.*, 2020), as follows:

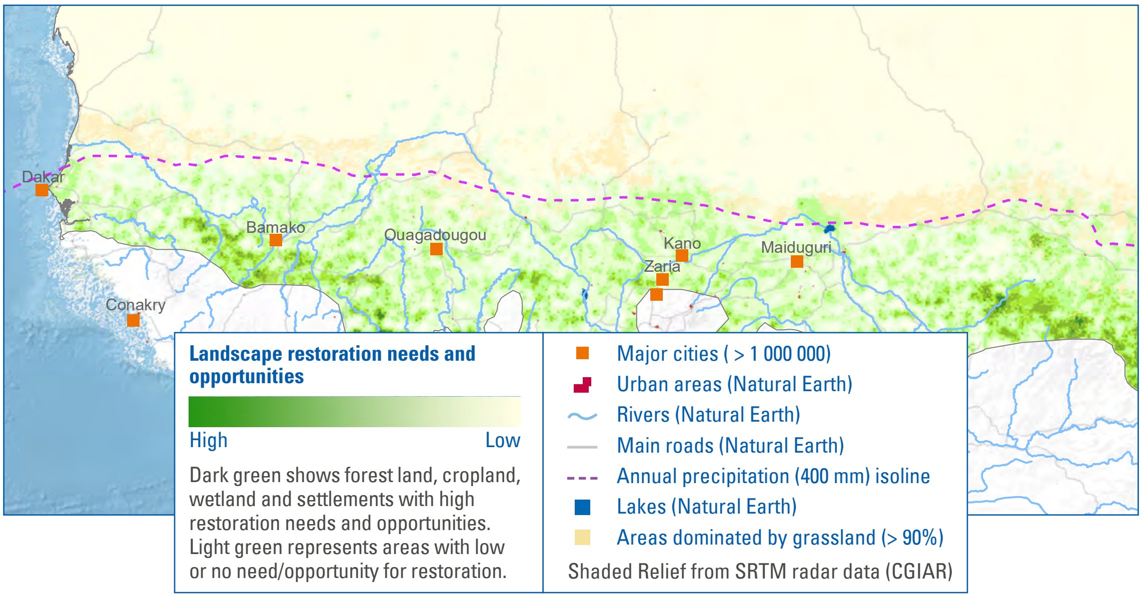
1. The **Bonn Challenge** was launched by the Government of Germany and the International Union for the Conservation of Nature in 2011 with the aim of restoring 150 million ha of degraded and deforested lands by 2020 and 350 million ha by 2030 across the world. Four of the G5 Sahel countries, all bar Mauritania, have pledged their commitment to this challenge, aiming to restore 23.3 million ha across them (The Bonn Challenge, 2023).

2. The **African Forest Landscape Restoration** began in 2015 to support the African Union Agenda 2063, the Bonn Challenge and the Sustainable Development Goals. The same four countries of the G5 Sahel have pledged to restore the same areas as in the Bonn Challenge (afr100, 2023).

3. The most eye-catching and well-known of these initiatives, the **GGW**, which spans the Sahel, including not only the G5 countries but also Djibouti, Eritrea, Ethiopia, Nigeria, Senegal and the Sudan. Within this large region, with a core area of 780 million ha, 21 percent of land is regarded as needing restoration, first and foremost by increasing tree densities. Figure 3.5 shows GGW ambitions in the western Sahel. The strategy agreed by participating countries in 2012, backed by the African Union in 2013, envisages restoring 10 million ha year: one-quarter in arid zones and three-quarters in semi-arid zones (FAO, 2016).

Overarching frameworks for these initiatives include the United Nations Decade of Ecosystem Restoration (2021–2030), United Nations Convention to Combat Desertification (UNCDD) Land Degradation Neutrality programme (UNCDD, 2023), New Partnership for Africa's Development's African Resilient Landscapes Initiative (World Bank, 2015) and FAO's Action Against Desertification (FAO, 2023) which supports implementation of the GGW.

Figure 3.5 **Landscape restoration in the western Sahel, Great Green Wall initiative**



Source: FAO. 2016. *Building Africa's Great Green Wall*. Rome, FAO.

3.4.2 What measures are needed?

FAO, in its Building Africa's GGW (2016), outlines the tasks to restore landscapes as follows:

- **Promoting natural regeneration**, in which farmers protect and manage the natural regeneration of native species in forests, croplands and grasslands (most likely to be effective in the dry subhumid and semiarid zones).
- **Investing in large-scale land preparation and enrichment planting** where degradation is so severe that natural vegetation will not regenerate on its own; communities select the native woody and grass species to be used (most likely to be required in the arid and semi-arid zones).

- **Fighting sand encroachment by establishing and protecting native woody and grassy vegetation** adapted to sandy and arid environments (most likely to be required in the hyperarid zone).
- **Mobilizing high-quality seeds and planting materials** of well-adapted native species to build ecological and social resilience.

Physical measures need also to be complemented by:

- **Developing comprehensive value chains that benefit local communities** and countries and enable the flourishing of green economies and enterprises.
- **Building inexpensive, participatory information systems** to support baseline assessments, identify interventions, track progress, inform stakeholders and investors, and aid learning and adaptive management.

Two competing visions of what should be done, and how, emerge (Botoni *et al.*, 2010; FAO, 2016; Flintan, Diop and Coulilbaly, 2020; Reij and Winterbottom, 2015).

One approach sees regeneration starting with technical specialists, such as foresters, who will plan what is to be done, set up nurseries to grow the seedlings to be planted, direct groups of locally hired labourers to plant the trees and fence plantations against browsing animals. The specialists will monitor progress, and every year hire gangs of local labour to maintain the growing trees. The new plantations may at some point after establishment be entrusted to local communities, who will be asked to protect and maintain them, but only after the specialists have designed and created the plantations.

This vision has critics (see, for example, Reij *et al.*, 2020). Their prime concern is that local communities, which ultimately will be responsible for the improved landscape, are disempowered. The communities have little or no say in the planning: there may have been some form of consultation but to inform the locals rather than allow them to decide. For implementation, local people are just hired as casual labour, and only once the trees are planted are they then expected to protect and maintain them. In all of this, they have next to no ownership of process or trees and, more critically, little say in what gets done, which plots to treat, what trees to regenerate or plant, what spaces to be left for migrating herds. Flintan, Diop and Coulibaly (2020) observe that in both Senegal and Mali, GGW interventions and activities are implemented top-down, with decisions about location and type of activities decided by the responsible GGW and local government agencies and with little consultation with local land users. Tree-planting has been a key area of focus of the GGW to date, normally without including local land users beyond the planting trees through cash-for-work programmes and fencing off the areas thereby excluding them from local use.

The result can be seen in evaluations that report that regenerated plots are, from the local point of view, in the wrong places, planted with trees that are not very useful. What has been planned and implemented from the top down is often seen as alien to locals, an imposition; hence, the resulting woodlands are neither protected nor maintained, and most of the trees planted do not survive.

The alternative vision is to work with communities, to allow them to select areas for regeneration and the tree species they value, to give them ownership of process and property. **These lands are, after all, their commons: it should be their right to decide on their use.**

The extension of this argument (see Reij and Winterbottom, 2015) states that, if the aim is to increase the density of trees, then why not encourage farmers to grow more trees on their fields, especially those species such as *Faidherbia albida*, which complement their crops? Such agroforestry, which converges with environmentally sustainable agriculture, gives individual farmers the incentive to conserve and enhance their lands, while raising more trees. Trees that have benefits not only for the farmland but also for local ecology beyond the field boundaries.

The former top-down vision (as described by Flintan, Diop and Coulibaly, 2020) fits well with national plans and targets to plant so many ha with trees, to restore so many ha of degraded or threatened land. This fits with the views that only some specialists know how this can be done, while farmers do not.

In the past, this vision has prevailed, but there are signs that the tide is turning, and increasingly even authorities in distant capitals are coming to appreciate that the latter vision, one of local empowerment, is the better way to achieve the ends in sight.

This change of emphasis can be seen for the GGW (FAO, 2015; ILRI, 2020). When the initiative was first conceived, some saw it as akin to large-scale civil engineering, it would indeed be a wall, a swathe of dense trees a few kilometres wide planted on the margin of the arid areas, to insulate semi-arid areas from the southward march of desert. With time, the vision has become the Wall as a metaphor for enhancing landscapes over a much wider swathe. A wall that can be as much as 100 km wide, with lands enhanced variously by planting forest and woodlands, or by working towards an agropastoral landscape in which vegetation in its various forms (woodlands, shrub, grazing and crops) will cover the ground to protect soil against erosion and encourage water infiltration: a landscape with more trees and more biodiversity.

The value of restoration lies partly in the value of higher yields for crops in agroforestry fields, in forest products (wood, fruit, etc.), in enhanced functioning of the ecosystem, and in avoiding the considerable costs of land degradation. For the

Niger, for example, Nkonya, Mirzabaev and von Braun (2016) make these estimates that the cost of land degradation due to LUCC is about 2007 USD 0.75 billion, which is 11 percent of the 2007 GDP of USD 6.773 billion and 1 percent of the 2001 value of ecosystem services in the Niger (…). While the cost of action to address land degradation is USD 5 billion while the cost of inaction is about USD 30 billion over the 30 year planning horizon. As expected the returns for taking action are quite high. Every US dollar invested in taking action returns about USD 6, a level that is quite attractive.

For the whole of the Sahel, we have this estimate from Mirzabaev *et al.* (2022) and the results show that the average annual costs of land degradation due to LUCC in the entire Sahel region during 2001–2018 period were equal to 3 billion USD. Every USD invested into land restoration is found to yield from 1.7 USD to 2.9 USD. About 10 years are needed for all land restoration activities to reach positive benefit-cost ratios from the social perspective. The amount of investments needed for land restoration across the Sahel is estimated to be between 18–70 billion USD.

Although Mirzabaev *et al.* (2020) run no fewer than 8 scenarios, which vary by length of time and discount rate, the longest time examined is 30 years, and the lowest discount rate is 5 percent. For this to be the most favourable scenario is conservative: the benefits of conserving land usually last much longer than 30 years and, if land is very well conserved, the benefits persist indefinitely. While 5 percent discounts the future heavily, it biases the analysis in favour of present generations and disregards the interests of those yet to be born, indeed, in some economies, it may exceed the average return to capital (in real terms).

Even so, taking these parameters, the benefit–cost ratios for biome restoration are high (Table 3.7): from 2.5:1 for restoring woodland to more than 6:1 for cropland and more than 7:1 for wetlands.

Table 3.7 **Benefit–cost ratio of restoring biomes averaged across the Sahel, computed over 30 years, at 5 percent discount**

Biomes	Benefit–cost ratio	Biomes	Benefit–cost ratio
Forest	5.4:1	Shrubland	3.6:1
Wetland	7.1:1	Cropland	6.4:1
Woodland	2.5:1	Grassland	4.3:1

Source: Authors' own elaboration based on Mirzabaev, A., Sacande, M., Motlagh, F., Shyrokaya, A. & Martucci, A. 2022. *Economic efficiency and targeting of the African Great Green Wall*. Nature Sustainability.

These analyses may understate the benefits, because they are based on estimates of ecosystem services of the different biomes, which, while they do include some direct provisioning, may undervalue non-timber products of the forest from activities that are not usually well recorded. Woodlands in Chad, for example, can produce an array of such produce (see Box 3.6).

Box 3.6 Non-timber produce in rural Chad

The following are collected from trees and other plants in Chad(*):

- gum arabic, from *Acacia senegal* – an estimated 480 000 tonnes a year;
- shea butter, from *Vitellaria paradoxa* – an estimated 834 000 tonnes a year;
- tamarind, from *Tamarindus indica* – an estimated 960 000 tonnes a year;
- fruit of *Balanites aegyptiaca* – an estimated 900 000 tonnes a year; and
- spirulina, an edible alga, from Lake Chad – an estimated 400 000 tonnes a year.

(*) Note: There may be 2.3–2.8 million future jobs in collecting, processing and packing these products. The products, other than spirulina from the lake, can be found in similar ecologies across the Sahel.

Source: Chad country report, see Chad matrix in Appendix A: Green Climate Fund. 2019.

3.4.3 What is the potential to create new jobs?

The potential creation in jobs depends on the areas that might be regenerated and the amount of labour required. On the former, so far we have been able to find targets only for Mali and the the Niger, planning documents for the GGW partnership provide figures only for the whole of the Sahel and not for individual countries or for the G5 Sahel.

Mali has targets for natural regeneration and reforestation of 5 million ha and restoration of degraded lands and consolidation of sand dunes on 3 million ha.

The Niger has targets for restoration by 2030. Planting up and restoring forests on 2.8 million ha, managing another 2 million ha of forests, encouraging agroforestry on 1 million ha of croplands and restoring 1.5 million ha of degraded land.

The total of full-time jobs in establishing and planting can be estimated at a little more than 1 million jobs, over the 7 years remaining – an annual average of 150 000 full-time equivalent jobs, with annual maintenance work of 486 000 jobs: 636 000 jobs a year in all.

If the Niger's ambitions were replicated over the other 4 countries, then as many as 3.18 million jobs a year would be created across the G5 Sahel.

Table 3.8 **Regeneration in the Niger: estimated jobs**[17]

Targets to be reached by 2030	Area (ha) (a)	Days per hectare		Full-time jobs, at 200 day a year	
Forests		Planting, initial work (b)	Annual maintenance (c)	Planting, initial work (d = a x b)	Annual maintenance (e = a x c)
Planting	1 800 000	65	22	585 000	198 000
Regeneration	1 026 000	10	5	51 300	25 650
Management of existing forests	2 000 000	-	22	-	220 000
Agroforestry	1 000 000	5	1	25 000	5 000
Restoring degraded lands	1 500 000	50	5	375 000	37 500
Totals				**1 036 300**	**486 150**

Source: Authors' own elaboration based on 2023 Niger country report and 2022 Mirzabaev *et al*.

3.4.4 What needs to happen to make this change?

Land restoration is already policy across the G5 Sahel. To implement it, however, requires both capital and organization. Investment costs can be estimated for the Niger (see Table 3.9). Capital costs come to USD 2.1 billion, or USD 301 million per year over 7 years, and USD 1.2 billion in annual maintenance.

These are very large sums indeed, sums that would be difficult to cover from the Nigerien government budgets. Donors have promised more than USD 14 billion to implement the GGW, but this is to cover all of the Sahel. Even this large sum, when shared across the region, would not cover the USD 2.1 billion investment

[17] Economic efficiency and targeting of the African Great Green Wall. *Nature Sustainability*, 5(1): 17–25, assuming that half of the costs are labour, and that labour is paid USD 5 a day. For agroforestry, the time taken is based on planting 50 trees per ha of arable. Time for regeneration assumes it is farmers who carry this out: estimated time from Chris Reij. Land restoration labour is taken as the average of time to install stone lines or semi-circles (see Section 3.3).

estimated for the Niger. In all likelihood, the targets set would have to be scaled back to something more affordable.[18]

Table 3.9 **Capital and current costs of regeneration in the Niger**

Activities	Area (ha) (a)	Planting, initial work (USD per ha) (b)	Annual maintenance (USD per ha) (c)	Planting, initial work (USD 000s) (d = a x b)	Annual maintenance (USD 000s (e = a x b)
Planting	1 800 000	645	225	1 161	405
Regeneration	1 026 000	645	225	662	231
Management of existing forests	2 000 000	-	225	-	450
Agroforestry	1 000 000	50	10	50	10
Restoring degraded lands	1 500 000	154	50	231	75
Total	**7 326 000**	-	-	**2 104**	**1 171**

Source: Authors' own elaboration based on 2023 Niger country report and 2022 Mirzabaev *et al*.

The organizational challenge is no less formidable as to plan and implement works across millions of ha requires many field workers. A major choice, as mentioned earlier, is to what extent these measures can be decentralized to local government (communes) and communities. However, even if powers and budgets were to be passed down to the communes, the programme would still require technical guidance, with extensionists in forestry and ecology posted locally to work alongside staff from the communes and people from the affected communities. There are 265 communes (in which 214 are rural) and around 12 700 villages in the Niger. It is hard to imagine the scale of public effort requiring anything less than 1 extensionist for every 10 villages, 1 700 in all.

[18] Much depends on how far the costs presented in Mirzabaev *et al.* (2022) resemble actual costs in the Niger. The authors of the paper have scoured the literature to find costs of dryland regeneration for different biomes across Africa: they found 15 sources. Nkonya, Mirzabaev and von Braun (2016) provide an alternative estimate, not broken down by biome or type of regeneration, as follows: "The cost of action to address land degradation is USD 5 billion while the cost of inaction is about USD 30 billion over the 30 year planning horizon." Their USD 5 billion is thus twice the figure presented above, albeit over a much longer period, of 30 years.

Land rights become a critical element in land restoration, an element that has two dimensions. One is that local people will restore their fields and commons only if they feel that these are their lands, from which they reap benefits, and over which they can set rules on use. For example how much firewood members of the community can remove from local forests, how many stock can be grazed on the commons and how these livestock are to be controlled to prevent damage to fields.

In parts of the Sahel, land rights to common lands are not well defined, with different jurisdictions setting overlapping sets of norms. The central state may have laws that award the state eminent domain over any common lands; communes may have powers that the leaders believe allow them to award lands and set rules for land use; councils of elders in villages may regard village lands – that in the Sahel may extend several tens of kilometres distance from the village – as under their control. When, in the past, populations were low and land per head was plentiful, the ambiguities over land usually did not matter. More recently, as rural population density has built up and people increasingly search for land, the risk of disagreements and unjust outcomes, with some people losing their rights to land they have long used, mounts. (See Toulmin, 2020 for a detailed account of overlapping and ambiguous land rights in a village north of Ségou, Mali.)

The other face of land tenure concerns the rights of nomadic and transhumant pastoralists to move their livestock seasonally. When these groups move into areas of crop farming, they need marked routes, and agreed rules on where they can move, where they may graze and where, to protect crops, they should not move. When these matters are not agreed, conflicts between farmers and herders can break out.

Arriving at tenure norms that respect longstanding rights, that protect minorities and people with little power against more powerful persons usurping their land, that mitigate potential disputes between crop farmers and herders, is not something that can be done overnight. Ideally, it requires much consensual discussion among those with rights and claims. It can, however, be done, and it can complement land restoration, as Reij *et al.* (2020) report, in Burkina Faso and the Niger, 17 local conventions at the commune (rural district) level now support sustainable landscape use, strengthen responsive decentralized governance, and reinforce rights and responsibilities. This has led to improved resource management, increased farmer-managed natural regeneration, and, most importantly, has reduced violent conflicts by an average of 74 percent in targeted communes.

The premise is clear, care and patience with rights, preferably with decentralization of powers to local forums, can be allied to land restoration in order to reduce the menace of conflict and violence.

3.5 Fisheries

Fishing may not be an obvious green opportunity across the G5 Sahel, with four out of five countries landlocked, but the large rivers and lakes of the region mean that fishing is more common and more valuable, and could generate more jobs than might be imagined.

For example, in the Niger, some 410 000 ha are covered by rivers – the Niger especially – and lakes, including access to Lake Chad. Some ponds, as many as 1 200, exist as well. It is estimated that 500 000 persons earn their living from fishing (Niger country report, 2023).

Some potential exists to expand fisheries, including aquaculture by digging ponds and farming fish. Also small-scale fish farming may be integrated with other farm activities, using by-products from crops and wastes to feed the fish.

Gauging the potential for fisheries development and additional jobs has proved elusive as fisheries activities are not well recorded in national statistics, nor are their economic or social characteristics reviewed for the study.[19] The country reports though note the following potentials:

- **Chad:** stocking of fish in dams and other structures that collect water, development of 85 ponds, with, all told, the potential to generate 65 000 extra jobs paid at USD 500–800 a year.
- **Mali:** potential to produce 200 000 tonnes of fish a year, doubling the current estimated 100 000 tonnes, with the possibility of thereby creating 50 000 more jobs in fishing, fish farming and processing.
- **Mauritania:** coastal waters that are highly productive. Currently, 66 000 persons fish, but it is hard to expand production or employment because quotas apply to captures. Nevertheless, some potential exists to create 5 280 more jobs by 2025 compared with in 2020: in fishmongering, from 2 000 to 3 000; in industrial processing, from 8 000 to 10 000; in fish scaling, from 800 to 1 000; in shipyards, from 340 to 420; in dock workers from 4 500 to 6 200; and in artisan processing, from 2 200 to 2 500.

[19] Literature searches show articles on the biology and ecology of fish in the G5 Sahel but rarely on fisheries as an economic or social activity.

- **Niger:** expansion and intensification of fish farming from the 1 200 ponds already in place. Current production is estimated at 45 000 tonnes a year, employing 40 000 persons in semi-intensive fish farms (1.5–2.5 tonnes per ha a year) and 10 000 in intensive fish farms (5–10 tonnes per ha a year).

The number of jobs likely to be created in fisheries is considerably fewer than for the four previous axes of transition, surely welcome additions but an order of magnitude lower.

3.6 Recycling rural waste

In all five countries, recycling rural waste was identified as part of a rural green transition (country reports, summary matrices in Appendix A). Wastes and by-products from plants, animals and kitchens may be converted to compost or to organic charcoal.

For example, in the Niger, the *Economic Empowerment of Refugees and Host Communities* project, funded by the country's Office of Population, Refugees and Migration, in 2019 supported sustainable waste management. It established two waste collection, sorting, compacting and recovery units; developed an above-ground composting system; and promoted the production of organic charcoal. Some 258 persons were supported (Niger country report, 2023).

Recycling has not been investigated in further depth, because it is hard to imagine it would generate many full-time job equivalents. There may well be scope for rural households to take their wastes and convert them to compost or charcoal, but this would probably be an extra household activity taking someone half an hour or less a day. Further, few households would employ people to do this.

3.7 Multipliers

When economic activity increases, it usually stimulates multipliers in additional activity and jobs in the local economy. Multipliers arise from links. When farmers increase output, this creates more activity in supply chains, both in providing farms with inputs and services and in trading and processing the extra produce marketed. Although some multipliers from rural areas may benefit the urban economy, some act locally. For example, if farmers invest in irrigation pumps, mechanics to repair them will be in demand, and they are more likely to be based locally than in a distant city.

Another, often the more powerful, link arises through consumption. When farmers spend extra earnings, much may be spent locally. They may, for example, contract masons and carpenters to improve their houses, spend more on their children's education, visit local market centres spending on transport on the way there and on food and drink when they arrive, and so on.

Thus, when agriculture grows, the non-farm economy usually grows as well. Estimates show each USD 1 of additional value added in agriculture generates USD 0.60–0.80 of additional non-farm income in Asia, and USD 0.30–0.50 in Africa and Latin America (Haggblade, Hazell and Reardon, 2007). Reviewing studies from rural Africa, Snodgrass (2014) arrives at a median estimate of 1.5 for the multiplier: studies using varied methodologies have placed the average value of the multiplier in sub-Saharan Africa around 1.5. That is, a USD 1 increase in agricultural income, brought on, say, by an investment or technological change, can raise national (or in some studies, non-farm rural) income by USD 1.50.

Linkages from production to local services become stronger when additional income is spent locally, which tends to happen when rural households start from low incomes – immediate needs often include locally sourced better foods, housing, schools for children and so on – and when they are isolated from cities. This may be weakening in contemporary Africa, as industrial consumer goods manufactured far from the village are increasingly demanded such as mobile phones, TVs, motorcycles and now solar panels.

For the purposes of this study, a multiplier to jobs of 1.3 has been applied, taking the value that Haggblade, Hazell and Reardon (2007) reported; Snodgrass estimated a value of 1.5 but that was for the whole economy: a rural multiplier would be less.

3.8 Summarizing potential employment

If the potential employment estimated for the four main axes of transition are summed, then it may be possible to create 8.2 million jobs (full-time equivalent) in investments and installation, and in O&M, adding in another 30 percent for jobs created rurally through multipliers (Table 3.10).

This may be compared against the projected entry of 11.4 million new entrants to the labour force over 5 years and 24.8 million over 10 years (see Section 1.1).

Clearly, a rural green transition could make a large contribution to meeting the demand for work.

Table 3.10 **Summary of potential employment creation across the G5 Sahel countries to 2030**

Axis	Installation	Annual equivalent over 7 years	O&M	Total annual employment
Rural solar power	247 413	35 345	98 965	134 310
Irrigation				
• Farm work (a)	5 700 000	814 286	1 140 000	1 954 286
• Technical support	-	-	2 850	2 850
Environmentally sustainable agriculture and climate-smart agriculture	3 200 000	457 143	560 000	1 017 143
Land restoration (b)	5 181 500	740 214	2 430 750	3 170 964
Total	-	**2 046 988**	**4 232 565**	**6 279 553**
Apply multiplier, 1.3	-	2 661 083.84	5 502 334.50	
Grand total				**8 163 418**

Notes: (a) 10 day per ha installation; (b) Lower-bound estimates (Table 3.8)

Source: Author's own elaboration.

4

Implications and policy recommendations

4.1 Appreciations

For the four main axes of transition considered, not only there are good returns to making transitions but also more than 8 million jobs may be created for young people in the coming years. Five key points stand out:

1. **Most of the changes needed are already underway to some extent.** In no case a transition depends on radically new activities requiring skills and competencies scarce in the Sahel. The need is not to start new things but to accelerate what is, in some places, already in progress.

2. **For some activities, the people of the G5 Sahel countries are already leaders in innovation, even if this is not always widely known or renowned.** Many thousands of Sahelian farmers have pioneered for the past 40 or so years, various initiatives focused on restoring landscapes, conserving soil and water on farms, planting more trees within farms and villages. In seeking guidance and expertise to take such measures forward, learning from the best and most innovative famers and from local leaders should provide lessons and inspiration.

3. **In yet other aspects, the Sahel has the potential to lead the world – above all with solar energy.** Some hydro plants are running in the region, and solar panels are becoming quite common in towns and villages. The potential for hydro plants is though limited due to issues related to the availability of suitable sites on rivers, instead, the potential for solar is large and widespread, given the abundant sunlight that the Sahel receives. As emphasised by the AfDB: "*Desert to Power* will make the Sahel the world's largest solar production zone."(AfDB 2022b).

4. **Many of the changes require neither central direction by the state nor large-scale public funding** – with one notable exception. Key drivers of change will be demand from rural households accompanied by firms seeking business and profit, solar energy and irrigation being excellent examples. Rather than try to drive (or control) such change, the state needs to accompany, monitor and nurture it, acting where it needs to act: to resolve problems of collective action and to provide public goods.

5. **The exception comes with land restoration**, where some of the value of improvements accrues as public goods and externalities whose benefits reach well beyond the field or village boundary, biodiversity and carbon capture being global public goods. These benefits also persist well beyond the usual horizon of business planning, whereby returns are expected within five or so years. A strong case can be made for public investment in these activities. Moreover, given that some benefits are international, they should be funded in considerable part by international agencies and funds.

On **employment and the prospects for youth**, four questions arise.

First, **will these jobs be accessible for youth?** Of the 8 million jobs, the great majority involve work on the land, in the fields, on the commons. They concern irrigation, sustainable intensification of farming with applications of agroecology and stimulating the natural regeneration of vegetation on degraded land. The skills needed are largely those familiar to anyone raised on a farm, in a village.

That said, those skills are largely tacit skills, that older generations need to pass down to youth. The danger is that youth, who are easily distracted by novelty and ideas from across the world, may be unwilling to learn from their elders, disparaging such knowledge as something from a bygone age. Ways must be found to counter this, some possibilities are discussed in the recommendations section.

Some jobs will require technical skills. For solar energy installation and O&M, technicians need to know (some of) the science that lies behind the technology; they need instruction in the practical skills necessary to install and maintain the panels. These are similar skills to those of electricians: workers require formal training, complemented by apprenticeships to develop skills on the job.

To back up an expansion of irrigation, to support farmers conserving and enhancing their land and to accompany local groups working to restore their local landscapes, more extensionists will be needed. In addition to training in agronomy, ecology and forestry, such technicians need orientation on working with people to facilitate processes, for example to chair farmer field schools or similar, rather than to instruct farmers by rote learning.

Second, **will these jobs be accessible by young women?** Only a few jobs call for unusual physical strength, the rest can be done by either gender. That said, many of these activities will be seen as men's work because, variously, they call for strength, they entail physical hazards or they involve skills, such as electrical or mechanical abilities, that some think to be masculine. Few of the jobs are seen as jobs for women, the exceptions being unenviable tasks such as weeding fields or laboriously pricking out tree seedlings.

Overcoming rigid conceptions of jobs partitioned by gender often needs a medium- to long-term effort, with women demonstrating their competence in jobs considered to be for men playing a leading role. To ensure women exercise such roles, quotas could be applied when it comes to training and hiring solar technicians and extensionists or else, where half of the places on courses should be for women.

Third, **will these jobs be well paid and attractive to youth**? The stark answer is that most of the jobs on the land will not be well paid; some youth will disdain them for low pay, for keeping them in the village and for being associated with farm labour that has long been hard (and sometimes dirty) work. The technical jobs, rather than jobs on the land, are those that will probably attract ambitious rural youth.

That admitted, two closely related things need to be borne in mind. One is that farm wages in parts of the world where economic growth has been relatively strong over the past 40 years have been rising, as has been seen in East and Southeast Asia. This is partly because of the generation of large numbers of jobs off the farm, either locally in the rural non-farm economy or in the cities. Labour shortages in agriculture are now quite common in countries such as Bangladesh, where a generation ago people were prepared to work on the fields for very low wages indeed (Wiggins and Keats, 2014).

The other point is that, as labour becomes short, jobs on the land become mechanized (Biggs and Justice, 2015), a process facilitated by Asian industrialization reducing the real costs of machinery for farms and villages across the world. Irrigation pumps and the motors that drive them, two-wheeled cultivators and small motorcycles that can be ridden down bush tracks: all of these are far cheaper today (in real terms) than they were a generation ago. These things are commonplace today in some parts of the global south, even though a few decades ago few imagined that this would come to pass. Some of them can already be seen in the Sahel: cheap irrigation pumps and motorcycles for example. The changes took place not because of some overnight transformation, the arrival of an unprecedented new technology, but through gradual but sustained growth of the economy, both agricultural and industrial, both rural and urban, with profound effects.[20]

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[20] For an account of these changes in rural Thailand, and their considerable consequences for the lives of rural women, see Fox *et al.* (2018).

Some of these jobs may initially require manual effort for low pay but with time, and assuming sustained economic growth, wages will rise and machinery will increasingly be used to ease the work.

Fourth, **will these jobs be accessible by youth living with disability?** Most of the employment considered here requires being physically able, work on the land is not well suited to people with restricted mobility. Their prospects for employment will lie more with jobs created through multipliers, in services demanded by farmers and fishers with more income from their activities.

4.2 Recommendations

Before presenting specific ideas to consider, some thought needs to be given to how to accelerate the transitions that are underway. Transitions may look difficult to leaders and those who help them make policy. The technical detail can be daunting; a plethora of enabling regulations may need devising and implementing for some changes; and getting donors to invest in these changes may be difficult, especially when donors expect every detail to be sorted out before they approve funding. Politically, the voting public needs convincing that changes are necessary and will benefit the majority over the medium term, especially when short-term alternatives appear politically more rewarding. Faced by this, leaders will be tempted to pay lip service to good intentions, sign up to grand initiatives, perhaps call for more studies, but then set things aside as the distractions of everyday business take precedence.[21]

This often being the case, **how can progress be made?** Here are some suggestions.

First, because some changes are already underway, driven by individuals, households, farms and firms, consult with those in the vanguard of change. Consulting leaders, managers and others who are already making the changes, to gain their appreciations of critical matters for public policy, may well be more productive than commissioning further studies or drawing up comprehensive plans that add only minor detail, and only after some time, to what is already known.

Some of what may be needed may not require costly or difficult state action: it may instead just need some obstacle to be removed, for example exempting green inputs from a tax, cancelling a subsidy or deleting some not-so-necessary regulation.

[21] The GGW, for example, was launched with a fanfare, with bold targets agreed across the participating nations. Results to date, however, have often been an order of magnitude less than what has been targeted.

Second, some changes require only making progress on existing priorities. For example, farmers wanting to irrigate need access to capital. Efforts to improve rural finance are longstanding – encouraging formal savings, lubricating credit and overcoming the market failures[22] that separate deserving farmers from the small loans they need.

In such cases, new actions may not be needed, it will be necessary instead to review experience, to identify where to make the next push. This does not necessarily mean transforming systems, a daunting challenge. The next step may be quite small. For example, if farmers are to invest in irrigation, in pumps, pipes, perhaps well drilling and so on, things that require investments measured between USD 500 and USD 5 000, can the equipment be leased to farmers, so that they in effect pay as they go? Instead of trying to arrange 10 000 small credits directly to farmers, can much larger loans be granted to a half-dozen suppliers to allow them to lease out equipment?

Specific suggestions

To promote solar energy, work with industry – with importers or sellers of equipment – to deal with any bottlenecks and blockages. Supply chain forums that bring together importers, installers, electricity companies and representatives of consumers with government can be a way to identify problems and opportunities, and to discuss potential solutions.

Where international public goods are being created, investigate the opportunity for a GCF and other typologies of vertical funds to finance activities. In particular, obtaining carbon payments for farmers who capture carbon should be a prime goal, even if it may take some years to achieve. It is unlikely any one government will be able to make sufficient progress on this: instead, form networks and working commissions across Africa to combine ideas and to put pressure on donors and international funds to take action. Within Africa there are centres of thinking that can take this forward – Akademiya, AGRA, the Forum for Agricultural Research in Africa, the Consultative Group for International Agricultural Research centres, the United Nations Environment Programme, etc.

Some tasks that may be needed to forge the link between the funds and actions on farms and villages may be attractive jobs for youth. For example advising farmers and village councils on how they may qualify for payments; helping source any technical help they need; monitoring, verifying and reporting on what has been

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22 Above all, the reluctance of banks to give loans to farmers when they do not know anything about the latter's competence and moral character.

done in the field. Such jobs could be rewarding to youth determined to lead in the fight against global heating.

If farmers and communities can be paid for their services on behalf of their nations, their region and the world as a whole, apart from the financial reward this should help promote pride in Sahelian achievements, which deserve more appreciation across Africa and beyond. The combination of payments with pride may well inspire local youth to value the knowledge and innovations of older generations, to make them interested to follow in their footsteps, where possible building upon and improving what their parents and grandparents have achieved.

Reorient existing extension staff in agriculture and forestry agencies, towards greener practices and towards working alongside farmers. If necessary, get them to take pride in local innovations, recognizing the considerable achievements of Sahelian farmers in pioneering ways to conserve soil and water.

Looking locally for innovation and taking pride in what has been achieved by Sahelian farmers does not, and should not, lead to ignoring formal science. Important advances have been made in recent times using sophisticated technology to understand natural resources in the Sahel – in detecting land use change through remote sensing, in assessing groundwater supplies through magnetic resonance soundings, in understanding teleconnections in regional climates allowing much-improved weather forecasting. The insights from these advances need bringing together with understandings at field level: a role exists for local and regional think-tanks to broker the two domains of knowledge, and to steer the scientists towards addressing priorities as seen from below, to prompt them to ask better and more productive questions.

Decentralize any public spending on land restoration as far as possible instead of spending through central ministries, give more to communes, empower them to take decisions and provide technical support – so they can devise what needs to be done locally to restore local landscapes, with all the adaptations to context this entails. In the 2010s, trials of decentralized climate finance were undertaken in Mali and Senegal that showed that this could be done (DCF Alliance, 2019). Decentralization may produce disparate local practice, and sometimes will lead to failure, but it may equally lead to unexpected successes, hence the following recommendation.

Invest in monitoring change in rural areas, reviewing what is changing, why and how. Look for innovations being tried in the field to find better ways of working, with even greater benefits. Do not underestimate or ignore the ingenuity and drive of some local actors: they are a key asset in making the green transition.

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Appendix A: Countries matrix for rural green transition

Burkina Faso

Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Renewable rural energy	▸ Solar energy: - Burkina Faso has significant potential for solar energy. Assuming production of 4–6 kWh per m^2 per day, an area of 1 km^2 receives gross energy of c. 1 500 GWh per year. Solar energy solutions have become appealing thanks to technical progress and an increased interest in preservation of the environment. It is used for lighting, water extraction and functioning of small processing units. In addition it can be widely used for households and small-scale irrigation. The sector offers a great opportunity for jobs for young people in the sale, installation and maintenance of solar energy and hydraulic equipment. - Zagtouli solar power station produces 33 MW of energy, being the biggest solar power plant (with solar panels) in West Africa, with energy potential of 55 000 MWh per year. - The factory at Kossodo for manufacturing of 60–100 solar panels per day is the leading factory of this kind in West Africa.	▸ Electrification: Several rural communes are demanding supply and installation of solar panels (a potential of 8 000 villages). This will require the training of 8 000 solar installers + installation of 1 500 backup solar systems (ANEREE, 2021). ▸ To support small-scale irrigation and household use: A few private businesses exist for manufacture/sale of solar installations at modest prices. ▸ Businesses processing local products: there exist several cooperative companies with a simple format (called SCOOPS) through which women produce non-timber forest products (NTFPs) in the 13 regions of Burkina, which are keen to be supplied with solar equipment for the processing of NTFPs. The project Women and Sustainable Energy, funded by the European Union, has enabled 20 SCOOPS to increase turnover through enhancement of their production and processing capacities (CEAS Burkina, 2021).	▸ Security of access to the sites. ▸ Expansion of existing units. ▸ Creation of new units. ▸ Training of technicians. ▸ Funding support. ▸ Adaptation of the offer of equipment to the purchasing power of target populations. ▸ Connecting businesses to markets. ▸ Availability of operating funds. ▸ Support to emerging initiatives.	▸ Technicians for installation and repair of solar equipment. ▸ Business/ sales people for solar equipment and material. ▸ A business unit comprises on average 3–5 persons (set-up of equipment, drilling, pumping trials).	▸ Gross margin between FCFA 75 000 and 300 000 (c. USD 125 and 500) according to the size and scope of the activity.	▸ Training in maintenance of solar equipment. ▸ Training in manufacturing of solar equipment.

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Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Renewable rural energy	Hydroelectricity: - Bagré Dam (16 MW) and Kompienga Dam (14 MW) in the east of Burkina. Total energy generation capacity of both dams are of 30 MW (ARSE, 2014).	Production of electricity for the city of Ouagadougou. Special agro-industrial zones benefiting from particular tax incentives and customs rules. More than 30 000 ha benefit from these dams, half of which have been developed into agricultural areas, zones for pasture and fishing ponds (comprising 30 percent of national fishing production).	Security of access to the sites. Rehabilitation of old infrastructure. Continuing extension of land for development. Increase in capacity to store water and put it through turbines. Establishment of financial and technical services. Adaptation of the offer of equipment to the purchasing power of target populations. Connecting businesses to markets. Support to emerging initiatives.	About 15 000 beneficiaries, including 5 000 women. Potential for 30 000 new jobs. Jobs on a yearly basis.	Agricultural minimum wage (FCFA 35 000, i.e. USD 60, per month), with double or triple of that for niche productions and jobs in fisheries.	Training of technicians and producers. Good agroforestry and fisheries practices. Training on niche activities. Access to information technology systems for marketing. Cooperative creation and management. Conflict management.
	- Samandeni Dam in the west of Burkina (3.74 MW) (ARSE, 2014).	Production of electricity for local development. Agro-industrial growth zones benefiting from special tax and customs regimes. 1 500 ha of irrigated land with a total potential area of 21 000 ha.		In time, 100 000 jobs (direct and indirect).		
	- Potential for hydroelectric power generation in multiple locations for a total of 72 MW (7 sites for development across the country) (ARSE, 2014).	Rural electrification. Water extraction for irrigation. Small and medium-sized units for production and processing of local products.		Ability to create about hundred jobs.	At least agricultural minimum wage.	

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Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Irrigation at small scale: farm and village irrigation	▸ Development of areas for market gardening in rural areas and drilling for extraction of water by solar pumps for the benefit of producers and women's groups. ▸ Development in urban and peri-urban areas of market gardening (tomatoes, onions, lettuce, cabbage, strawberries) as well as areas for growing fruit and flowers.	▸ Several projects of different sizes put into operation or on the point of being put into operation – one of the most significant being the project for small-scale irrigation in the west as well as the eastern region funded by Agence française de développement. The project is due to run from 2022 to 2027. Its aim is to develop for irrigation 2 950 ha of low-lying land (*bas-fonds*) and 682 ha of irrigated areas. ▸ 100 ha cultivated in the capital around 3 dams that cross the city as well as small seasonal water retention areas in a surrounding area of 25 km.[23]	▸ Security of access at the sites. ▸ Support to producers' organizations, particularly of women to operationalize the sites. ▸ Facilitation of access to the means of production (equipment, materials and finance). ▸ Links with networks and interdisciplinarity: producers, material suppliers, government information services, financial services, NGOs, researchers. ▸ Connecting businesses to markets. ▸ Technical advice and support to producers. ▸ Promotion of ecological production techniques.	▸ Agronomists with skills in water management. ▸ Engineers specialized in rural areas. ▸ Economists and sociologists. ▸ Agricultural advisers. ▸ Technical and commercial advisers.	▸ Wages vary from the minimum agricultural wage (USD 60, per month) to twice that for high-value agricultural products such as onions and chilies. ▸ Agricultural wage up to FCFA 500 000 per month (c. USD 800) depending on the products (strawberries, fruit trees).	▸ Innovative irrigation techniques. ▸ Ecological production techniques (access to bio-inputs and improved seeds). ▸ Conflict management.

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[23] Source: producers at dams in Ouagadougou nos. 1 and 3 interviewed by Dr TOE, M. Bernadette during research visits as part of the current study.

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Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Restoration and regeneration of the rural landscape	▶ Promotion of application of techniques and technologies for the restoration of soil fertility. ▶ Soil water conservation/ soil protection and restoration, assisted natural regeneration. ▶ Good practices for sustainable land management. ▶ Use of agroecology.	▶ The Great Green Wall Initiative.	▶ Security. ▶ Training. ▶ Support to NTFPs. ▶ Availability of land.	▶ 50–300 hours of work per ha depending on technique used. ▶ Aggregate collectors. ▶ Labour for infrastructure construction. ▶ Eco-guard.	▶ The agricultural minimum wage.	▶ Training on techniques in conservation of water in soils/ protection and restoration of soils. ▶ Training on tree nurseries.
Recycling of rural waste	▶ The abattoir of Ouagadougou: collection of the waste from the abattoir and processing into biogas. ▶ Rural households: collection of animal excreta and processing into biogas. ▶ Composting of the sludge from water treatment stations.	▶ Production of electricity of 550 KW attached to the public network supplying 2 000 households. ▶ Production and sale of digestat in the form of biofertilizer Nourrisol (Fasobiogaz, 2019).c. 15 000 biodigestors installed between 2010 and 2019 in households and small processing units (cooking, lighting).	▶ Training and awareness-raising of relevant actors (collectors, families, restorers, processors, producers). ▶ Dissemination of information on technologies. ▶ Installation of collection and transport equipment. ▶ Provision of equipment and materials for composting.	▶ 60 young technical/ commercial masons trained in 2022. ▶ Waste collectors and processors. ▶ Producers (especially in market gardening).	–	▶ Training on types of waste. ▶ Training in waste collection and sorting. ▶ Training in composting household waste.

Chad

Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Irrigation at small scale: farm and village irrigation	▸ Canal connecting the town of Bol to the lake (existing excavation).	▸ The canal is 36 kms in length.	–	▸ Small-scale equipment and materials X number of members of the household.	▸ 250 000 FCFA (c. USD 420) for the season.	▸ Training in entrepreneurship and small-scale irrigation management.
Environmentally sustainable and climate-smart agriculture	▸ Non-timber forest products:	–	▸ Equipment for the picking, collection, processing and conditioning (e.g. for food hygiene) and transport.	▸ Potential paid work for young people including young women.	▸ Remuneration for the pickers and collectors of these products, typically FCFA 50 000 for the season (c. USD 100).	▸ Training on picking, collection, processing and conditioning.
	- Arabic gum (*Acacia senegal, Acacia seyal*).	▸ 480 000 tonnes per year.	▸ Training in rural areas. ▸ Equipment for processors.	▸ 400 000 to 500 000 jobs created for this activity.		
	- Shea tree (*Vitellaria paradoxa*) potential in 7 regions.	▸ 834 148 tonnes per year, for processing into butter.	▸ Training in rural areas. ▸ Equipment for processors.	▸ 800 000–900 000 future jobs can be created.		
	- Tamarind fruit (*Tamarindus indica*).	▸ 960 000 tonnes per year.	▸ Setting up of semi-industrial units.	–		
	- Egyptian balsam (*Balanites aegyptiaca*.	▸ 900 000 tonnes per year.	▸ Increase marketing. ▸ Improve hygiene.	▸ 750 000–900 000 future jobs can be created.		
	- Spirulina (an edible alga).	▸ 400 000 tonnes per year.	–	▸ 400 000–500 000 future jobs can be created.		
Fisheries	▸ Priority options that have been identified include expanded fishing practice and fish-stocking in dams and water retention basins.	▸ Development of 85 ponds for fish production (Oreochromis – a species endemic to Africa and the Middle East).	▸ Mobilization of substantial investment and active participation by the private sector.	▸ 650 000 future jobs can be created.	▸ FCFA 300 000–500 000 (c. USD 500–800) per year.	▸ Training on the use of fisheries equipment (e.g. blower, fry production). ▸ Training in infrastructure maintenance (fish farms, water treatment technology).

Mali

Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Renewable rural energy	▸ Solar energy.	▸ 720 MW of potential. ▸ 6 kWh per m^2 (7–10 hours).	▸ Strengthening of capacities of existing actors. ▸ Easier access to appropriate funding sources. ▸ Support to emerging initiatives.	▸ 15 jobs per MW, 10 800 potential jobs can be created as: - Equipment and material suppliers. - Technicians in installation of solar systems (photovoltaic panels). ▸ Designers of systems adapted to the needs.	–	▸ Training or professional refresher courses in installation of solar equipment. ▸ Training in maintenance.
	▸ Transformation of biomass into renewable energy via biodigestors.	▸ 5 000 units of 2–4 m^3 each.	▸ Strengthening of capacities of installers of biodigestors. ▸ Easier access to appropriate funding sources.	▸ 2 jobs per unit.	–	▸ Training or refresher courses in installation and management of biodigestors.
	▸ Hydroelectricity.	▸ 1 150 MW of potential (only 22 percent currently in use).	▸ Capacity building for the identification, evaluation, feasibility study and design of hydroelectric developments and installations. ▸ Support to emerging initiatives (private–public partnerships and others).	▸ 10 jobs per MW, 11 500 potential jobs can be created.	–	▸ Training in prospection, feasibility study, and design and delivery of hydroelectric developments.
Irrigation at small scale: farm and village irrigation	▸ Construction or rehabilitation of small community water retention structures.	▸ 350 000 ha.	▸ Appropriate support and advice on prevention and management of conflicts related to the use of the land and water resources.	▸ 4 jobs per ha, 1 400 000 potential jobs can be created as: - Labourers for construction of the structures. ▸ Users and farmers of the new irrigated land.	–	▸ Training of stakeholders and supervisors on management of the new tools.
	▸ Drilling of boreholes and installation of systems to extract water, as well as appropriate modes of irrigation.	▸ 100 000 ha.	▸ Easier access to appropriate funding sources. ▸ Strengthening the capacities of relevant participants.	▸ 5 jobs per ha, 500 000 potential jobs can be created as: - Designer of systems. - Suppliers of equipment and materials. - Installation technicians. - Operators familiar with recommended techniques and good agricultural practices.	–	▸ Training in design and delivery of irrigation systems (spray, micro-jet, drip, low pressure "Californian" irrigation, gravity, etc.). ▸ Training of users in irrigation techniques and good agricultural practices.

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Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Irrigation: major projects	▸ Sokè II and Dioro I Ponds.	▸ 4 650 ha for the development and operationalization.	▸ Need for funding from the Malian government and its international technical and financial partners.	▸ 1 job per ha, 4 650 potential jobs created.	–	▸ Training and advice for farmers. ▸ Training and supervision of the managers of the water distribution system
	▸ Development of the M'Bewani Zone.	▸ 5 800 ha.		▸ 2 jobs per ha, 11 600 potential jobs created.		
	▸ Other big irrigation areas.	▸ 10 000–15 000 ha per year.		▸ 2 jobs per ha, between 20 000 and 30 000 potential jobs created.		
Restoration and regeneration of the rural landscape	▸ Promotion of natural regeneration and reforestation.	▸ 5 000 000 ha.	▸ Communication and information on appropriate techniques (e.g. field schools for rural farmers).	▸ 0.25 jobs per ha, 1 250 000 potential jobs can be created. ▸ Rural farmers taken on to protect trees in the fields and other areas without trees.	–	▸ Training for career development advisors.
	▸ Restoration of degraded lands and consolidation of sand dunes.	▸ 3 000 000 ha, essentially in rural areas and on the banks of watercourses.	▸ Easier access to appropriate funding sources. ▸ Access to appropriate materials.	▸ 0.30 jobs per ha, 900 000 potential jobs can be created.	–	▸ Training on restauration of degraded lands and consolidation of sand dune.
Fisheries	▸ Fish farming.	▸ 200 000 tonnes per year of potential, of which 100 000 tonnes is currently exploited.	▸ Easier access to appropriate funding sources and quality performance equipment.	▸ 0.5 jobs per tonne, 100 000 potential jobs per year as: - Suppliers of equipment and materials. - Fishers. - Transporters. - Traders. - Distributors.	–	▸ Training of suitable equipment manufacturers. ▸ Training of fishers, traders and distributors in hygiene and quality control.
Recycling of rural waste	▸ Recycling of rural waste.	▸ 2 000 000 tonnes per year of household waste in urban areas.	▸ A partnership framework between local authorities and private sector actors. ▸ Organization of the participants. ▸ Financial subsidies for equipment and materials for waste treatment and appropriate developments.	▸ 0.015 jobs per tonne, 30 000 potential jobs created per year as: - Waste collectors. - Screeners. - Composters. - Plastic recyclers. - Transporters. - Sellers.	–	▸ Training of waste collectors, screeners, composters and recyclers of plastics. ▸ Training of advisers and supervisors.

Mauritania

Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity, typically	Information available on salaries/ earnings	Training needs
Irrigation at small scale: farm and village irrigation	▸ Market gardening: for a long time Mauritania has been a centre for market gardening with potential for job creation in rural areas. ▸ Increase in processing of products from market gardening is a national priority.	▸ The existence of a number of associations and cooperatives, especially those of women, could boost this sector of activity, subject to financial support for their activities, and also different types of training.[24] ▸ Setting up new technologies and culturally appropriate techniques.	▸ Development of dams. Low levels of rural electrification have resulted in continuation of subsistence agriculture with a lack of modernization of the sector (with creation of small, modern farming and processing businesses). ▸ Access to loans for farmers. ▸ Innovative approaches to funding of climate-compatible small-scale irrigation that helps save water and preserve the environment as well as increase yields and productivity. ▸ Support for drip irrigation.[25]	▸ 6 000 additional jobs (for a total area of 13 000 ha).	▸ Agricultural labourers work for a wage per hectare (for planting, weeding, preparation and harvesting, etc.), or for a daily wage (USD 54 dollars per person per day). ▸ Technical workers on farms, especially vegetable farms, Mauritanian or foreign, are paid according to production.	▸ Training in market gardening (with a certificate of professional aptitude). ▸ Specialization in development of small agricultural plots (dikes and embankments and slopes, etc.). ▸ In the following locations – Guidimakha, Trarza, Gorgol, Brakna and the Oasis Areas – professional training programmes and techniques need to focus on: - Food value chain through the processing and conserving of market garden products. - Maintenance and repair of motor pumps for irrigation and market gardening. - Maintenance and repair of agricultural machinery.

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[24] Different types of support to small producers have certainly allowed them to continue to farm and to provide income for their families but not to increase market garden production nationally so as to meet demand. This will not happen without substantial investment and active participation by the private sector in intensive production on large areas.

[25] And introduction of technologies and cultural techniques sufficiently advanced to raise yields (protected crops = under covers or in glasshouses); use of seeds that can produce high yields; mechanization of farming practices; use of fertilizers of appropriate types and in optimal quantities; putting in place of infrastructure for storage, processing and appropriate logistics for distribution, etc.

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Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity, typically	Information available on salaries/ earnings	Training needs
Environmentally sustainable and climate-smart agriculture	▸ The ongoing FAO project entitled "Integrated ecosystem management programme for the sustainable human development in Mauritania" has activities such as: - Sustainable practices while combatting climate change and environmental degradation in agriculture, forestry and fisheries. - With a main outcome on strengthening capacities on ecosystem management of national services and local authorities in the "triangle of hope" of the biological reserve El Atf and of the GGW Initiative. - Priority domain of the initiative is resilience. In addition to its work in water scarcity and small-scale agriculture.	▸ Locations of intervention of the project: Monguel, Kaedi and Maghama in Gorgol region; Barkeol in Assaba region; Aleg and Maghta Lahjar in Brakna region. Project interventions on: - Agriculture, forestry and fisheries. - Planning and integrated and participatory management for sustainable development of ecosystems. - Conservation, restoration and sustainable management of rural landscapes. - Reduction of pressure on ecosystems through revenue generation and financing mechanisms. - Management of information.	▸ Total amount of financing: USD 30 363 381. ▸ From the Global Environment Facility: USD 8 222 505. ▸ Appropriate policies on e.g. food security and adaptation to climate change including inter-sectoral coordination	–	▸ The jobs created by the project are mostly seasonal, with a salary from MRO 120 000 to 150 000 (USD 350 to USD 440).	▸ Training on vegetable gardening.

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Type of activity	Examples of activities	Dimension of the activity	Conditions required to support the activity	Jobs per unit of activity, typically	Information available on salaries/ earnings	Training needs
Fisheries	▸ The Strategy for Adaptation and Integrated Sustainable Development of the Marine Fisheries Sector 2020–2024 with job creation.	▸ There are funding sources available such as those of Promo pêche, Grepao, AG Pélagique, the European Union (institutional support to the fisheries agreements), the World Bank and the International Labour Organization, among others. ▸ Fisheries organizations include Fédération nationale des pêches, ▸ Fédération libre de la pêche artisanale.	▸ Support for the 66 000 fishers are not getting a raise due to fishing limits and quotas.	▸ 23 120 additional, new jobs by 2024–2025 according to the Centre de recherche océanographique. ▸ Fishmongers: c. 2 000 in 2020, increasing to 3 000 in 2024. ▸ Industrial processors: c. 8 000 in 2020 to 10 000 in 2024. ▸ Fish scalers: c. 800 in 2020 to c. 1 000 in 2024. ▸ Shipyards: 340 in 2020 to c. 420 in 2024. ▸ Dock workers: 4 500 in 2020 to c. 6 200 in 2024. ▸ Artisan processors: 2 200 in 2020 to 2 500 in 2025.	▸ Fish scalers: independents, invoicing by kg. ▸ Fishmongers: treated as independent businesses who sell on the fish following purchase from the fishers. ▸ Dock workers no fixed salary, as they are paid for each unloading.	▸ The holders of all these jobs listed here may be professionally trained in their areas of work via established training programmes.

Niger

Type of activity	Examples of activities	Dimension or expected unit of activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Renewable rural energy	▸ Hydroelectricity.	▸ 130 MW with an annual production of 630 GW hours.	▸ Strengthened security.	▸ 6 jobs per MW, around 780 potential jobs created (source: Revised CDNs).	–	▸ Hydroelectric engineer. ▸ Maintenance.
	▸ Solar energy.	▸ 250 MW.	▸ Extension of training with financial support. ▸ Adapt the offer of solar energy according to the purchasing power of different people and communities. ▸ Support to emerging initiatives.	▸ 6.21/MW (jobs per year), 1 552 potential jobs created.	–	▸ Training in maintenance of solar energy pumps and assembly of solar equipment.
	▸ Transformation of biomass into renewable energy by biodigesters.	▸ 150 MW.	▸ Extension with development of organic matter through the combination of agriculture and cattle breeding. ▸ Exchange of information with producers.	▸ 0.4/MW (jobs per year), 60 potential jobs created.	–	▸ Training in the maintenance of biodigesters.
Irrigation at small scale: farm and village irrigation	▸ Rehabilitation of irrigation areas (seuils d'épandage).	–	▸ Development of seed banks for forestry and village tree nurseries. ▸ Adaptation and equipping of irrigated areas with appropriate physical structures. ▸ Viable maintenance and repair.	–	–	▸ Strengthening of skills relating to use of techniques such as drip irrigation.
	▸ Areas of land under small-scale irrigation (ha).	▸ 38 000 ha from 2021 to 2025, i.e. an average of 7 600 ha per year (Plan d'Action 2021–2025 de l'Initiative 3N, 2021).	▸ Funding availability. ▸ Improved management of groundwater for agropastoral production.	▸ 3.03 jobs per ha (calculation based on the information that the construction of the 6 600 ha of the Kandadji dam will generate more than 20 000 jobs).	–	▸ Training on the conservation, processing and marketing. ▸ Training in rational management of irrigation water. ▸ Training in crop pest management.
	▸ Area of hydro-agricultural developments - and floodplains developed (ha).	▸ 148 000 ha from 2021 to 2025, i.e. an average of 29 600 ha per year.				

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Type of activity	Examples of activities	Dimension or expected unit of activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Irrigation: major projects	▸ The Kandadji project.	▸ 5 400 ha of irrigated areas to be developed in return for land. ▸ Development of 45 000 ha of irrigated areas by 2034 with an average of 1 000–2 000 ha per year.	▸ Ministry of Agriculture project: funding for the personnel and the works: xUSD 1 300 000. ▸ An increase in communication and information maintained. ▸ Integrated crop pest management.	▸ Construction of the dam. ▸ Preparation of the fields to be irrigated: 50 days/ha. ▸ Operation of the irrigated area: 3 jobs per ha. ▸ Total 3 000 jobs created.[26]	–	▸ Training and practical guidance on irrigation methods for farmers. ▸ Training and practical guidance for the personnel who operate the dam and the system of water in water-saving irrigation methods.
	▸ Project for the renovation of the Konni irrigated area.	▸ 2 452 ha to be renovated as part of the implementation of the Compact Programme of the Millennium Challenge Corporation 2019–2021.	▸ Improve the conditions of the preparation for marketing and the marketing itself.	▸ 2 per ha expected according to the report of the revised nationally determined contribution (NDC) – (total of 4 904 jobs created).	–	–
	▸ Hydroagricultural development projects of the National Agency.	▸ 16 000 ha in a total of 76 hydroagricultural developments.		▸ 2.5 per ha according to the report of the revised NDC (around 40 000 potential created).		
Restoration and regeneration of the rural landscape	▸ Promotion of natural regeneration.	▸ 1 million ha, comprising 50 million trees in agroforestry by 2030 including 57 112 ha between 2011 and 2020.	▸ Extension, via schools of practical agriculture.	▸ 0.03/ha during 6 months (around 30 000 jobs potentially created).	–	–

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[26] Calculation made on the basis of an average of 1 500 ha developed per year and an estimate of 3 employees required for 1 ha.

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Type of activity	Examples of activities	Dimension or expected unit of activity	Conditions required to support the activity	Jobs per unit of activity	Information available on salaries/ earnings	Training needs
Restoration and regeneration of the rural landscape	▶ Restoration of degraded lands and consolidation of sand dunes.	▶ 1.5 million ha of rural lands restored by 2030 of which 408 640 ha of land restored between 2011 and 2020 and 581 998 ha of land to be restored from 2021 to 2025. ▶ 550 000 ha of dunes to be consolidated by 2030 of which 36 999 ha restored between 2011 and 2020 and 188 455 ha to be consolidated from 2021 to 2025. ▶ 750 000 ha of assisted natural regeneration (ANN) from 2021 to 2025, i.e. 150 000 per year.	▶ Availability of funds to pay for the labour and some supervision of the work.	▶ Between 0.08 and 0.12 potential jobs per ha up to 2030 (calculation based on the information of creation of between 120 000 and 180 000 potential new jobs as stated in the revised CDNs (120 000/1 500 000 = 0.08 jobs). ▶ Between 0.18 and 0.27 potential jobs per ha up to 2030.	–	▶ Formal training on land restoration to future supervisors.
	▶ Half-moons in agricultural, forest and pastural contexts.	▶ 1.03 million ha of land (agricultural, forest or pasture).	–	▶ On average 80 person-days per ha.	–	–
	▶ Gum tree/ doum tree and Moringa oleifera plantations, grass sowing and private forestry.	▶ 1 800 000 ha of reforestry with different trees by 2030; moringa over 125 000 ha, sowing over 304 500 ha of paths and promotion of private forestry over 75 000 ha between 2020 and 2030.	▶ Communication and outreach, perhaps by schools of practical agriculture.	▶ Planting: 0.12/ha in the preparation phase. ▶ 0.06/ha during the 6 months of work. ▶ 10 days/ha.	–	▶ Instruction and advice to communicators, and more technical skills in transformation of NTFPs.
	▶ Control of invasive terrestrial plants.	▶ 57 112 ha carried out, 2011–2020.	–	▶ 0.15/ha during the 6 months of the work, potential of 8 570 jobs created.	–	–
Fisheries	▶ Fish farming.	▶ Yields of 1.5–2.5 tonnes/ha/ year by fertilization or by direct feeding in semi-intensive and 5–10 tonnes per ha/year in intensive fish farming basins.	–	▶ 0.56/ha directly or indirectly[27] in semi-intensive and 0.75/ha in intensive fish farming (direct and indirect jobs estimated at 50 000–40 000 in semi-intensive fish farming and 10 000 in intensive fish farming).	–	▶ Skills training and technical support.

[27] Calculation made by the author of the country study on the basis of a current average production of 45 000 tonnes per year, with the average return and the number of direct and indirect jobs estimated at 50 000 (40 000 in semi-intensive fish farming and 10 000 in intensive fish farming).

Inclusive Rural Transformation and Gender Equality (ESP) Division
Economic and Social Development
www.fao.org/rural-employment

Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-138002-4
9 789251 380024
CC7033EN/1/07.23