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COMPLETE SCALING READINESS STUDY OF LASER-ASSISTED LAND LEVELLING IN UZBEKISTAN

July 2023

german cooperation
DEUTSCHE ZUSAMMENARBEIT
Implemented by:
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Science for resilient livelihoods in dry areas
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Key Words
Scaling Readiness, Innovations, Scaling, Governance, Evaluation, Laser-assisted Land Levelling, Irrigated agriculture, Uzbekistan

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ABBREVIATIONS AND ACRONYMS

AKIS	Agricultural knowledge and innovation system
AR4D	Agriculture research for development
CEN	Central-Eastern Europe and Central Asia
CGIAR	Consultative Group on International Agricultural Research
CSA	Climate-smart Agriculture
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GVA	Gross Value Added
ICARDA	International Centre for Agricultural Research in Dryland Areas
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IRL	Innovation Readiness Level
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
KM	Knowledge Management
LLL	Laser-assisted land levelling
MoA	Ministry of Agriculture
MoWR	Ministry of Water Resources
NASA	National Aeronautics and Space Administration of the United States of America
NENA	Near East and North Africa
NGO	Non-Governmental Organisation
R&D	Research and Development
SDG	Sustainable Development Goals of the United Nations
SRL	Scaling Readiness Level
UL	Use Level
UZS	Uzbekistani Som (1.00 US Dollar ~ 11,500 UZS – July 2023)

PREFACE

This study is a part of the Eco Aral project: Ecologically oriented regional development in the Aral Sea region, of the ICARDA Central Asia and Caucasus Regional office, and it was financed by GIZ as commissioned by the Government of the Federal Republic of Germany. The Eco Aral project supports the governments of Kazakhstan and Uzbekistan to ensure ecologically sustainable and climate-resilient economic development across borders. All activities are carried out in close collaboration with regional, national, and local institutions of the public and private sectors as well as national and international research institutions.

In this study, we apply the Scaling Readiness approach. This is a decision support system designed to support international research for development projects and programmes implemented by CGIAR in designing, developing, disseminating, and improving the use of innovations at scale. Scaling Readiness is distinguished from other approaches in innovation and scaling with its three pillars, i.e. i) using evidence on the assessment rather than expert opinion, ii) dealing with impact ambitions through an innovation lens, and iii) being empowered by the Technology Readiness tradition established by NASA and used by among others EU Research and Innovation Programs like Horizon 2020 and Horizon Europe. For the science dimensions of Scaling Readiness, the research paper by Sartas et al. 2020[1] and the Scaling Readiness Guide[2] can be helpful. Recent case studies in Africa on genetic solutions for tropical poultry[3], the Natural Resource Governance Framework and Sustainable Natural Resources and Livelihood Programme in Sudan[4] and the study on Conservation Agriculture System in Moldova[5] can give some practical examples on the application of the Scaling Readiness method. More information can also be found on the scaling readiness website:
www.scalingreadiness.org

SCALING READINESS LEXICON

The Scaling Readiness approach provides a step-wise process for designing, validating, and implementing scaling strategies (see Figure 1). The advantage of a stepwise process is that it breaks down the development of a scaling strategy into smaller, manageable steps with specific objectives (s), methods, and results. This allows for a transparent process that can easily be communicated to project teams and collaborators. As the results of activities and partnerships aimed at scaling an innovation can only be forecast to a limited extent, Scaling Readiness continuously monitors whether scaling strategies achieve the desired effect. This report doesn't cover all steps of the Scaling Readiness approach; it focuses on steps 1, 2 and 3: the characterisation of laser-assisted land levelling within the context of Uzbekistan, a diagnosis in terms of its scaling readiness and some suggestions that can help to derive a scaling strategy. Since Scaling Readiness has multiple innovative concepts and indicators that can be new to the reader, they are explained in this Scaling Readiness Lexicon that has been adapted from the Scaling Readiness Guide[2].

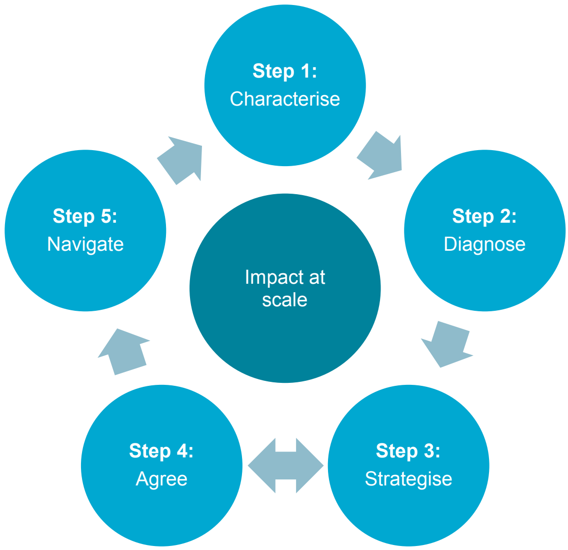

Figure 1: Overview of Scaling Readiness approach as a stepwise process (adapted from Sartas et al. 2020 [2])

Complementary Innovations: Additional technologies, practices, or infrastructures that work with the core innovation to enhance its effectiveness and facilitate its adoption and scaling. These innovations provide support, fill gaps, or address other aspects necessary to implement and utilise the core innovation successfully.

Core Innovation: The core innovation refers to the central technology or solution that forms the foundation of a particular innovation. It represents the primary innovation that addresses a specific problem or achieves a desired outcome. Core innovations often consist of several different components.

Evidence-based measurement: Measures in Scaling Readiness are calculated using rigorous evidence. Specific claims of Readiness and Use measures are assessed through a hierarchy of sources of verification. High-quality science articles and other peer-reviewed documents are the first sources. In their absence, technical documents or other publicly scrutinised documents are used to back up specific evidence claims. In the lack of documents, multiple experts' opinions with proven competencies are triangulated to identify the measures.

Innovation: A novel product, service, or arrangement with economic, environmental, health, industrial, etc. benefits. Innovations are different from inventions since innovations have successful implementations. A product, service, or arrangement must have a clear use objective to be considered an innovation. Innovations can be technical or social. They can be tangible and intangible. In Scaling Readiness, innovations are characterised, diagnosed, and strategised. research for development interventions work on science-based innovations. Science-based innovations differ from the others in that they have systematic scientific documentation about what they are made of and how they work. Also, information on them is available for public scrutiny. Research for development interventions can control or strongly influence scientific innovations' design, development, and delivery and catalyse or support their use at scale.

Innovation component: Knowledge, technology, a concept, practice, etc., that constitutes a part of innovations. Innovations can have many features. Some of them are novel and play critical roles in the functioning and use of the innovation in the contexts the intervention operates for achieving specific intervention goals. Some components of a more extensive innovation can be stand-alone innovations in other contexts. In Scaling Readiness, these novel components of innovations are identified, characterised, and diagnosed. Research for development interventions can control or significantly influence innovation components' design, development, and delivery.

Innovation Package: The combination of the core innovations an intervention aims to design, develop, and deliver with other complementary innovations necessary to use them at scale makes up an innovation package. Innovation packages usually consist of technologies and other products, services, and organisational and institutional arrangements required to improve awareness of accessibility, affordability, and other characteristics of an innovation that influence the functioning and use at scale. The innovation package is the fundamental unit of analysis for scaling innovations in Scaling Readiness. Research for development interventions can influence the design and delivery of innovation packages, but they cannot control it. Many innovations in the innovation packages are beyond the control and influence zone of interventions; therefore, partnerships are vital in improving the overall Scaling Readiness of Innovation Packages.

Innovation Readiness Level (IRL): A measure that indicates how mature or practical an innovation is to achieve its use objectives. It can be considered a systematic answer to the question, "How well does an innovation function?" It can be between 0, which indicates that the innovation is just an idea in the mind of its potential designers and developers, and 9, suggesting that the innovation is a proven innovation with clear evidence of its value measured in terms of livelihood impact profit, etc. Research and development projects increase Innovation Readiness Levels by improving the design of the innovations and developing and validating the improved designs in uncontrolled and controlled conditions.

Innovation Use Level (UL): A number indicating the level of the application of an innovation at scale. It can be considered a combined answer to the question, "Who uses an innovation, and in which order of magnitude?" It can vary between 0 and 9, with 0 indicating that the innovation is not being used and 9, which suggests that the innovation is commonly applied by its end-users who were not involved

in any innovation design, development or dissemination processes. Research and development projects increase existing innovation use levels by disseminating knowledge and expanding the use of innovations by other innovation professionals who were not involved in the same projects and users who were not involved in any innovation processes. The Innovation Use Level can be considered an advanced measure for the adoption of innovations. It combines the adoption with the support provided by the projects. It includes a diversity of other innovation users to be a more valid estimate of the use potential of an innovation at scale. In conventional impact assessment, adoption is measured by the number of people, households or organisations using an innovation regardless of their involvement in the project's activities supporting the innovation. Most international development projects provide innovations free of charge or provide significant financial and non-financial incentives. Therefore, the adoption of the innovation by the stakeholders supported by the projects is not a valid indicator of the potential use at scale of an innovation. There is a high chance that, once the provision of the innovation or the strong incentives is stopped, the number of users will decrease dramatically. In addition, several stakeholders who use the innovation are not sufficiently considered in conventional impact studies. In the early maturity phases of an innovation, a significant number of researchers, designers, developers, and supporters, such as trainers and extension officers, use the innovation. As the number of these people increases, the likelihood of the use at scale gets higher in the middle and long term, even if the number of final users is the same in the short term.

Intervention: A coherent set of planned activities for achieving specific goals in a defined period within a particular space. An intervention is a general name of a project. Although most interventions are projects, there are other types of interventions, such as programmes, a specific combination of projects for achieving higher-level objectives, and initiatives that refer to a set of planned activities, usually without explicitly specifying goals and periods. Scaling Readiness can be used for different types of interventions, e.g., projects, programmes, and policy interventions.

Scaling Readiness Level (SRL): A single number combining the Readiness and Use level of all the innovations in an Innovation Package. It can be considered a single answer to the question, "What is the likelihood that an innovation package will achieve impact at scale?" There are different ways of calculating the Scaling Readiness levels based on the management system's preferences. It can be an average level, a minimal level, or a weighted average level. This study documented two Scaling Readiness levels: the average Scaling Readiness Level and the Scaling Readiness score. The Average Scaling Readiness Level is the multiplication of the averages of the individual Innovation Readiness and Use levels of components or innovations. The Scaling Readiness score is the multiplication of the Readiness and Use levels of the minimum level component or the innovation in the package. Scaling Readiness score is a stricter version focusing on the minimum. It aims to help the designers of the interventions prioritise the bottleneck components or innovations that hinder the high impact at scale.

Bottleneck Component or Innovation: A subset of components in the innovation package that perform the worst and are used by fewer users than the other components or innovations. In Scaling Readiness, the bottleneck components of an innovation or the bottleneck innovations in an innovation package are used to prioritise the activities of research for development interventions to achieve maximum impact at scale with minimum cost and resource use. Bottleneck components and innovations are not universal and depend on the specific time, space, and goals. Identifying Scaling Readiness levels and the Scaling Readiness score present the set of bottlenecks.

Characterisation: Characterisation is the first step of the Scaling Readiness cycle. It includes the activities to document and classify three critical units, i.e., interventions, innovations, and stakeholders. In this study, we focus on only one of these three crucial units: the core innovation components and the complementary innovations are characterised using a customised version of Scaling Readiness step 1.

Diagnosis: Diagnosis is the second step of the Scaling Readiness cycle. It includes assessments of the characteristics of the interventions, innovations, and stakeholders generated in the first step and the implications of these characteristics in achieving impact at scale. Diagnosis of the innovations and Innovation Packages are made in this study using a customised version of Scaling Readiness step 2

Strategising: Strategising is the third step of the Scaling Readiness cycle. It includes identifying tailor-made fit-for-purpose strategies for addressing the diagnosis step and improving the impact at scale performance using a set of hierarchical strategic options. Strategising is done partially in this study by using a customised version of Scaling Readiness step 3.

User-Based Reporting: Scaling Readiness informs international impact investors, managers of projects, programmes, and policies working on innovative solutions to livelihood problems, designers, developers of innovations, monitoring, evaluation, learning and impact assessment professionals who are involved in projects, programmes and policies including innovative solutions and researchers studying innovations and their impact. To tailor the content to the needs of these users, Scaling Readiness books and reports are organised into four major parts below.

Strategic Innovation Management Options: Scaling Readiness offers an integrated set of management options for enabling the most effective and cost-efficient decisions to improve the Readiness and Use of innovations and innovation packages. An intervention's first three options are substitute, outsource, and insource, which are ordered from the most effective and efficient towards the least. The second set of three options is relocate, reorient and postpone, which are more comprehensive and require sponsor consultation and agreement. The second set of options is considered if the first set is not feasible. If the second set of options is also not possible, the remaining option for the intervention is to stop. Stopping is an important option that needs to be considered to prevent the waste of valuable resources that can be used to improve livelihoods in other ways.

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EXECUTIVE SUMMARY

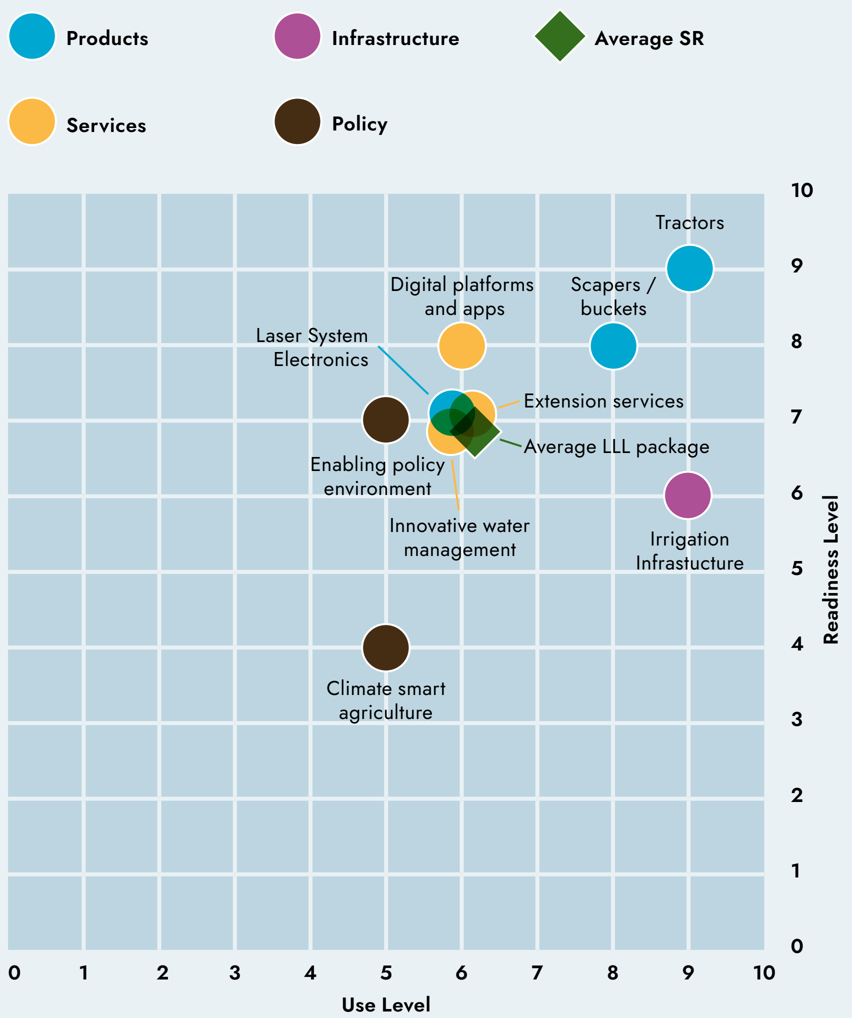
KEY FINDINGS

laser-assisted land levelling (LLL) is an innovative technology that utilises laser-guided equipment to create a precise and uniform land surface. This technology has been successfully implemented in Uzbekistan, contributing to improved crop yields and increased farm productivity. It offers several advantages over traditional levelling methods, such as improved irrigation, increased crop yields, reduced soil erosion, and lower labour costs. However, there are also challenges, including high initial costs, technical expertise requirements, weather sensitivity, and maintenance needs. The government has recognised the importance of LLL and made significant investments, including establishing training centres and subsidies for LLL equipment. By scaling LLL, Uzbekistan aims to modernise its agricultural sector, improve productivity, and contribute to environmental sustainability by reducing water and fuel consumption.

In the context of Uzbekistan, the successful scaling of LLL depends on not only the quality of the core innovation components: the tractors, scraper and buckets systems and the laser and electronic parts, but also the complementary innovations, including: 1) innovative water management technologies, 2) rural irrigation infrastructure, 3) an enabling policy environment (subsidies, extension services, land tenure and tractor parks), 4) climate-smart agriculture practices, and 5) digital platforms/ICT integration. These innovations complement the LLL technology by improving irrigation, supporting sustainable land management, facilitating knowledge sharing, and enhancing agricultural productivity and efficiency.

Figure 2 shows that the average scaling readiness of the complete LLL package is 7 for the Innovation Readiness level. The average Use Level is a bit lower: 6,35. These scores indicate that the scaling readiness of Laser-assisted Land Levelling is relatively high, with mature technologies that have proven themselves in commercial settings and initial steps taken towards scaling within Uzbekistan. The National Agricultural Research System is aware of the benefits and ready to promote LLL among farmers, with some early adopters already using it. However, there are variations in the adoption across provinces. Sales data suggest a shift towards LLL, indicating a transition from pre-development to acceleration in the scaling phase for the core components. Low readiness scores, combined with high use levels, as is the case for irrigation infrastructure, highlight a problematic situation known as technological lock-in. This occurs when the adoption of an innovation becomes entrenched and difficult to change, hindering the uptake of alternative solutions, such as Laser-assisted Land Levelling (LLL).

Figure 2: Overview of Scaling Readiness scores of Laser-assisted Land Levelling



The outdated irrigation system in Uzbekistan creates a need for alternative irrigation methods, but farmers' limited willingness to switch is evident by the low use level of innovative water management approaches. While policy instruments show higher readiness levels on paper, their effective implementation could be better, and farmers' distrust in government policies, influenced by historical experiences, hampers their investment in technologies like LLL.

RECOMMENDATIONS

1. **Enhance Affordability:** LLL equipment is currently expensive, posing a barrier to scaling. To address this, both direct and indirect measures can be implemented. Direct measures include developing financial support programmes or subsidies targeting small farmers, thereby reducing the price burden of LLL equipment. Additionally, facilitating equipment-sharing models where farmers can rent or share LLL equipment can make it more accessible. Indirect measures involve long-term investment decisions, such as establishing a stable land tenure system and introducing fair water prices. To regain farmers' confidence in government policies, 'good governance' measures can be implemented, for instance, ensuring access to an independent judiciary in case of conflicts.

2. **Reduce Perceived Complexity:** The complexity associated with LLL is hindering its scaling. To overcome this, efforts should be made to simplify and streamline LLL technology. Capacity building, knowledge sharing, and awareness-raising are also crucial. Training programmes and technical support networks can educate farmers on LLL operation, maintenance, and troubleshooting. Pilot projects and demonstrations across regions can showcase LLL's benefits, instilling confidence and encouraging adoption. Integration of ICT tools, digital platforms, and apps enhances scaling by improving farm management, knowledge dissemination, and collaboration. However, this also requires shifting from the current top-down knowledge dissemination strategies towards more participatory approaches.

3. **Use LLL as a transition tool towards more efficient irrigation:** LLL offers a promising solution for improving irrigation efficiency, especially in the context of the existing canal-based infrastructure. Despite being often in a competitive relationship with other advanced irrigation techniques due to their high costs, LLL is technically very compatible with various existing irrigation approaches, making it a suitable transition tool. Implementing LLL within the existing system leads to immediate benefits like increased productivity and profitability. This gradual transition creates opportunities for adopting other innovative water management approaches.

4. **Embrace Climate Smart Agriculture as an opportunity for scaling**: Despite its low use level and innovation readiness, climate smart agriculture (CSA) offers a chance to scale LLL in Uzbekistan. LLL aligns well with CSA principles, emphasising sustainable and climate-resilient agriculture, efficient water management, and soil conservation. Integrating LLL with CSA initiatives provides access to existing international networks, technical expertise, and financial support, facilitating LLL adoption and contributing to its scaling efforts in the country.

GENERAL INTRODUCTION

BACKGROUND AND CONTEXT

The agricultural sector plays a crucial role in the economy of Uzbekistan, contributing significantly to the country's food security and the livelihoods of its population. In 2022, the primary sector (agriculture, forestry and fishery) accounted for 25.1 % of the total GDP. The agro-food sector provided about 30 % (4.2 million people) of the national employment [6], while the Gross Value Added (GVA) was 34.5 % or UZS 285,369 trillion, according to the agriculture annual report 2022 [7]. Adopting innovative practices and technologies becomes paramount with the increasing need for agricultural productivity and efficiency. One such innovation is laser-assisted land levelling[1] (LLL), a precision land management technique that offers significant benefits in terms of water conservation, enhanced crop yields, and resource efficiency.

LLL involves using laser technology to smoothen the land surface, creating a constant slope and achieving precision in land levelling. Farmers can achieve a highly accurate and uniform land surface using laser-equipped machinery, allowing for efficient water distribution and improved crop growth [8–10]. Laser-assisted levelling could be highly suitable for this particular region of Central Asia and Uzbekistan [11–16].

OBJECTIVES AND SCOPE

This project aimed to conduct a Scaling Readiness assessment of laser-assisted land levelling in Uzbekistan. By undertaking this assessment, the aim was to provide insights regarding the readiness and potential of LLL to contribute to sustainable agricultural development in Uzbekistan. Furthermore, the findings and recommendations of this study can serve as a resource for policymakers, agricultural stakeholders, and practitioners involved in promoting and implementing precision land management practices in the country.

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1 Laser-assisted, laser-guided, or simply laser land levelling are commonly used to denote the same technology. In this report, we will stick to the term laser-assisted land levelling.

The main research question addressed in this report is: ***How ready for scaling is laser-assisted land levelling in Uzbekistan, and what are the appropriate actions that could accelerate or enhance its scaling process?***

The report provides a comprehensive analysis of the current state of LLL adoption in Uzbekistan, assessing the readiness and potential for scaling up this innovative practice. It examines the enabling factors and barriers that impact the widespread adoption of LLL and provides recommendations on actions that could facilitate its scaling process. The scope of this assessment encompasses the organisational, technical, economic, and policy dimensions related to LLL in Uzbekistan. It includes an examination of the relevant stakeholders, institutional frameworks and regulatory environments influencing the adoption and scalability of LLL.

This report is divided into three parts, each focusing on different aspects of laser-assisted land levelling technology. In the first part, we delve into the innovation profile of LLL. We provide a comprehensive overview of the technology by analysing its most important features and key components. Subsequently, we highlight its advantages, disadvantages, and connection to the Sustainability Development Goals. Finally, we describe the complementary innovations that can hinder or facilitate the scaling of the LLL within the context of the agricultural sector of Uzbekistan.

Part B contains the technical heart of the report with the assessment of the Scaling Readiness of LLL. In this section, an in-depth look is taken into the Innovation Readiness and the Use Levels of the core components of LLL as well as the complementary innovations that can facilitate or hinder its scaling. This section presents a detailed Scaling Readiness Profile of LLL that contains an overview of the limitations and opportunities for scaling LLL in Uzbekistan.

Finally, Part C contains the Scaling Guidelines with Conclusions and Recommendations. This section offers practical guidelines for scaling LLL based on the assessment findings. These guidelines present actionable steps and strategies to overcome barriers and enhance scaling. Key considerations, such as policy support, capacity building, financing mechanisms, and stakeholder engagement, are outlined to ensure successful scaling implementation. The section concludes with a summary of the main findings from the innovation profile and Scaling Readiness assessment, followed by concrete recommendations for policymakers and stakeholders.

TARGET AUDIENCE

By reading through this report, readers will gain a comprehensive understanding of LLL, its potential applications, and the readiness for scaling in the specific context of Uzbekistan. The report aims to inform decision-makers, stakeholders, and practitioners involved in agricultural development, providing valuable insights to facilitate informed decision-making and support the sustainable integration of LLL for agricultural land management, including:

Government agencies and policymakers: Government agencies responsible for agriculture and rural development can gain insights into the potential of LLL and its role in achieving national agricultural goals. The analysis can support evidence-based policymaking, enabling the formulation of supportive policies, regulations, and incentives to promote the widespread adoption of LLL. Policymakers can also leverage the recommendations to design targeted interventions and investment strategies for scaling LLL practices in Uzbekistan.

For **international donor agencies**, the analysis can provide valuable insights for prioritising funding decisions, monitoring project performance, facilitating knowledge sharing, and influencing policy and strategies. By using the analysis outcomes on innovation bottlenecks, donor agencies can enhance the effectiveness and impact of their agricultural development initiatives, ultimately contributing to sustainable and resilient farming systems in the target regions.

Farmers and agricultural producers stand to benefit significantly from the analysis of LLL scaling readiness. They can gain a comprehensive understanding of the advantages, challenges, and requirements associated with adopting LLL techniques. The study can assist them in making informed decisions regarding the adoption of LLL, considering factors such as cost-effectiveness, technical requirements, and potential benefits.

Research institutions and academia involved in agricultural research can find value in the analysis as it provides insights into the current state of LLL adoption and the factors influencing its scalability. The findings can inform further research and innovation efforts, enabling the development of context-specific best practices, methodologies, and technological advancements in precision land management. Collaboration opportunities with stakeholders can also be identified to address research gaps and support evidence-based decision-making.

Agricultural extension services and advisory organisations are crucial in disseminating knowledge and providing technical support to farmers. These stakeholders can use the analysis to enhance their understanding of LLL and its potential impact on agricultural systems. The findings can guide the development of targeted training programmes, demonstration sites, and knowledge-sharing platforms, enabling them to support farmers in adopting and implementing LLL practices effectively.

Designers, developers and engineers: agricultural manufacturers and suppliers of agricultural machinery, including laser land levellers, can benefit from the analysis by understanding the demand, market potential, and specific requirements for LLL equipment in Uzbekistan. This knowledge can guide their product development strategies, distribution channels, and after-sales services. By aligning their offerings with the needs of Uzbekistan's agricultural sector, manufacturers and suppliers can contribute to the successful scaling of LLL practices.

Monitoring, evaluation, learning and impact assessment professionals: the analysis of LLL provides valuable inputs for MEL professionals in terms of baseline data, evaluation design, learning initiatives, intervention adaptation, and policy influence. The study can help MEL professionals to strengthen their monitoring, evaluation, and learning efforts, contributing to evidence-based decision-making and promoting effective implementation of LLL interventions.

Overall, the stakeholders mentioned above, among others, can benefit from this analysis by gaining a deeper understanding of the opportunities, challenges, and necessary actions for scaling up laser-assisted land levelling in Uzbekistan. It is also important to develop a shared understanding between international donors, private sector investors, national governments, local governments, producers' organisations, service providers and other stakeholders about the key characteristics and components of LLL.

Not every part of the report will be equally interesting for all stakeholders, and each part is targeted towards a specific audience, see Table 1.

Table 1: Overview of the report

PART A **Innovation Profile of LLL**	PART B **Scaling Readiness Assessment**	PART C **Scaling Guidelines**
Government agencies: project, programme and policy managers	Government agencies: project, programme and policy managers	Government agencies: project, programme and policy managers
	Donors and international development partners	Donors and international development partners
	Research institutions and academia	Research institutions and academia
Agricultural extension services and advisory organisations	Agricultural extension services and advisory organisations	Agricultural extension services and advisory organisations
Designers, developers and researchers of Innovations	Designers, developers and researchers of Innovations	
Farmers and agricultural producers		Farmers and agricultural producers
	Monitoring, evaluation, learning and impact assessment professionals	Monitoring, evaluation, learning and impact assessment professionals

PART

A

ANALYSIS OF LASER-ASSISTED LAND LEVELLING IN UZBEKISTAN

INNOVATION PROFILE OF LASER-ASSISTED LAND LEVELING

This part focuses on the description of the innovation. It aims to provide a deeper understanding of innovation-related dimensions of achieving impact at scale through laser-assisted land levelling by providing detailed information about laser-assisted land levelling in Uzbekistan, its potential advantages and disadvantages. This step results in a clearly defined innovation package consisting of the 'core' and the 'complementary' innovations of LLL in Uzbekistan.

Specifically, it presents the essential characteristics of LLL relevant to its performance at scale:

- An analysis of the key components of LLL that makes it an innovative solution for irrigated agriculture and water conservation, improving yields and increasing resource efficiency.
- A description of LLL within the context of the agricultural sector in Uzbekistan.
- An analysis of the complementary innovations, such as other products, services, organisational and institutional arrangements that are developed together with the core innovation and that influence the functioning and use at scale.
- The relationship of LLL within the larger Sustainable Development Goals (SDGs) of the United Nations.

These elements together build the "innovation package profile", which can be considered the first step of the Scaling Readiness Diagnosis. This part does not articulate the procedures and tools for identifying the Scaling Readiness measures and the evidence sources. More information about the measures can be accessed from the Scaling Readiness Evidence Review in part B. The assessment also does not articulate the implications of the findings for designing and implementing innovation and scaling projects, programmes and policies. The Scaling Readiness Guidelines (Part C) synthesise the findings and recommendations.

KEY FEATURES OF LASER-ASSISTED LAND LEVELLING

Laser-assisted Land Levelling (LLL), or laser levelling for short, is an innovative technology introduced in agriculture to level the land with precision and uniformity. LLL involves using laser-guided equipment to create a flat and even surface, which is essential for efficient water management and optimal crop growth. The technology has been successfully implemented in many countries, including Uzbekistan, where it has contributed to improving crop yields and increasing farm productivity.

Laser-assisted land levelling is a precise method of smoothing the surface of agricultural lands to an accuracy of ± 2 cm using laser-equipped drag buckets. This technique involves altering the field to create a consistent slope of 0 to 0.2 %. Laser-levelling requires specialised equipment, including a laser level, receiver, control panel, excavation equipment such as a tractor and scraper possible with a GPS receiver, and software. The specific equipment needed depends on the application and the level of accuracy required. The process begins with a laser transmitter that emits a rapidly rotating beam parallel to the desired field plane, see Figure 3. A sensor fitted to a tractor towards the scraper unit picks up the signal. It converts it into cut and fill level adjustment, which is carried out automatically by a hydraulic control system. The scraper guidance is fully automated, ensuring consistently accurate land levelling.

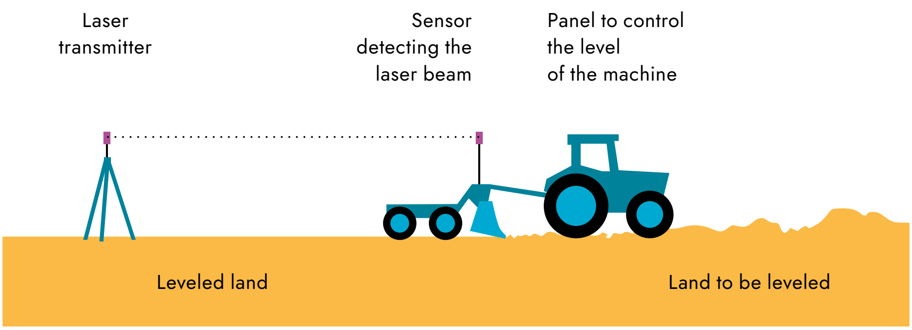


Figure 3 Schematic overview of laser-assisted land levelling
Source: Adapted from Cazanescu et al. 2010 [8]

An LLL system comprises mechanical and electronic components that work together to achieve precise land levelling. Here is an overview of the mechanical and electronic parts commonly found in an LLL system. The mechanical parts consist of the following:

Scraper Units: Scraper units are the primary mechanical components responsible for physically moving and reshaping the soil. They consist of cutting blades or buckets attached to a frame that can be raised or lowered to adjust the soil level.

Hydraulic Control System: A hydraulic control system operates the scraper units, allowing for precise adjustments in the soil elevation. It controls the scraper units' raising, lowering, and tilting movements, ensuring accurate land levelling.

Tractor: The scraper units are typically attached to a tractor or other suitable vehicle. The tractor provides the power and mobility to move the scraper units across the field.

Automatic Levelling Mechanism: LLL systems often incorporate an automatic levelling mechanism to maintain consistent scraper unit height and ensure uniform land levelling. This mechanism compensates for any irregularities in the terrain, maintaining a level surface.

The electronic components consist of the following:

Laser Transmitter: The laser transmitter is an essential electronic component in an LLL system. It emits a laser beam parallel to the desired field plane, acting as a reference level. The laser transmitter is typically mounted on a high platform, ensuring an unobstructed view of the field.

Receiver/Sensor Unit: The receiver or sensor unit is positioned on the LLL equipment, such as the tractor or scraper. It detects the laser beam emitted by the transmitter and measures the height or distance from the reference level. The receiver converts the received signal into a cut or fill adjustment.

Control Panel: LLL systems often include a control panel or console that allows operators to monitor and adjust various settings. The control panel may display real-time data such as elevation, slope, and cut/fill levels. It enables operators to make precise adjustments and ensures accurate land levelling.

Electronic Control Unit (ECU): The ECU is the central processing unit of the LLL system. It receives data from the receiver/sensor unit and controls the hydraulic system, coordinating the adjustments of the scraper units. The ECU interprets the received signals, calculates the required level adjustments, and sends commands to the hydraulic control system.

Power Supply: Electronic components of an LLL system require a power source to operate. This can be a battery, generator, or connection to the vehicle's power system, ensuring a continuous and stable power supply for the laser transmitter, receiver unit, control panel, and ECU.

PROS AND CONS OF LLL

Laser levelling can be considered an innovation in agriculture as it represents a significant improvement in creating levelled fields. Before the use of laser technology, levelling fields was done manually using traditional surveying techniques, which were time-consuming and often imprecise. Laser levelling, on the other hand, offers several advantages over traditional methods, including:

Improved irrigation: Level fields enable uniform water distribution, improving the efficiency of irrigation and reducing water waste. This can help to conserve water resources and reduce water bills for farmers.

Increased crop yields: Laser-levelling creates a uniform surface for planting, which ensures that crops have consistent access to water, nutrients, and sunlight. This can lead to increased crop yields and higher-quality produce, see Table 2.

Reduced soil erosion: Levelled fields have less slope and contour variation, reducing the risk of soil erosion caused by runoff. This helps to maintain soil fertility and reduce nutrient loss.

Reduced labour costs: Laser-levelling can be done quickly and efficiently using specialised equipment, which reduces the need for manual labour and can save farmers time and money.

Disadvantages:

High initial cost: Laser-levelling equipment can be expensive, especially for small farms. This can make it difficult for some farmers to justify the investment, especially if they have limited access to credit.

Technical expertise: Laser-levelling requires specialised knowledge and skills to operate effectively. This can be a barrier for farmers unfamiliar with the technology or lacking access to training. From interviews, we learned that this is also the case in Uzbekistan. Suppliers sometimes provide minimal training, after which some sensitive electronic components quickly malfunction through inadequate maintenance and operation.

Weather sensitivity: Laser-levelling is sensitive to weather conditions, such as wind and rain, which can affect the accuracy of the work. This can delay the process and increase costs, at least in theory.

Maintenance requirements: Laser-levelling equipment requires regular maintenance to keep it in good working condition. This can add to the overall cost of the equipment and may require specialised knowledge or training to perform.

Overall, LLL can be successfully implemented by all kinds of farmers: ranging from small-scale farmers to large mega-farms and agro-holdings. By adapting the scale of the equipment, the technology has enough flexibility to be interesting for all these types of farmers. This also means that the technology has no inherent 'scale advantage', making it only interesting for large farmers [17]. However, it should also be clear that the advantages and disadvantages are not distributed equally among different types of farmers. Larger farmers will more easily be able to come up with the money for the initial investment of the equipment and training of personnel.

Table 2 provides an overview of the estimated costs and revenues for two crops: wheat and cotton. It shows that the investment in LLL, despite its higher costs in mechanisation, more than makes up for these costs in yields and revenues. Although these figures are from 2010, farmers in our interviews claimed similar or even higher yield increases (30 %) after laser-levelling.

Table 2: Estimates costs and revenues of LLL

	Wheat				Cotton			
	Traditional levelling	1st year of LLL	2nd year of LLL	3rd year of LLL	Traditional levelling	1st year of LLL	2nd year of LLL	3rd year of LLL
Expenses on mecha-nisation	453.1	508.9	391.2	391.2	595.2	649.7	532.1	532.1
Expense on labour	63.9	49.1	49.1	49.1	113.2	100.4	100.4	100.4
Water use (m^3)	5725	4011	4011	4011	10000	8000	8000	8000
Irrigation expenses	72.8	53.1	53.1	53.1	90.8	71.9	71.9	71.9
Other expenses	500.5	520.2	520.3	520.3	572.1	621.1	621.1	621.1
Total expenses	**1090.3**	**1131.3**	**1013.7**	**1013.7**	**1371.3**	**1443.1**	**1325.5**	**1325.5**
Yield, c/t	40	44	44	44	25	27.5	27.5	27.5
Revenues	**1260**	**1386**	**1386**	**1386**	**1508.5**	**1659.3**	**1659.3**	**1659.3**
Profit	**169.7**	**254.7**	**372.3**	**372.3**	**137.2**	**216.2**	**333.8**	**333.8**
Profita-bility (%)	15.6 %	22.5 %	36.7 %	36.7 %	10.0 %	15.0 %	25.2 %	25.2 %

*) estimates per hectare in 2010; unless stated otherwise, all numbers are in 1000 UZS. Source: KRASS, 2010

RELATIONSHIP WITH SUSTAINABLE DEVELOPMENT GOALS

Laser-assisted land levelling can contribute to several United Nations Development Goals (SDGs) related to sustainable agriculture and rural development. Firstly, LLL can contribute to SDG 2 - Zero Hunger. By creating level fields with uniform soil moisture, LLL can improve crop yields, which can help increase food production and food security. This technology can also help reduce crop loss due to waterlogging or soil erosion, contributing to reducing food waste. Secondly, LLL can contribute to SDG 8 - Decent Work and Economic Growth. By improving crop yields, LLL can create new opportunities for agricultural employment and increase incomes for farmers. This technology can also enhance the efficiency of irrigation water use, which can help farmers save on water costs. Thirdly, LLL can contribute to SDG 13 - Climate Action. LLL can help mitigate greenhouse gas emissions from water pumps and flooded soils by improving soil moisture and reducing waterlogging. Additionally, LLL can help reduce soil erosion, preventing soil degradation and loss of carbon sequestration potential. Lastly, LLL can contribute to SDG 15 - Life on Land. LLL can help protect and restore soil fertility by reducing soil erosion and creating level fields. This technology can also contribute to preserving biodiversity by reducing the impact of agricultural expansion on natural habitats. In summary, LLL is a technology that can contribute to multiple SDGs related to sustainable agriculture and rural development. This technology can help increase food production and security, create new job opportunities, mitigate climate change impacts, and protect soil fertility and biodiversity.

APPLICATION OF LLL IN UZBEKISTAN

It is believed that laser-assisted land levelling was first introduced in Uzbekistan in the late 1990s, with support from international organizations such as the World Bank and the United Nations Development Programme. However, research papers on laser levelling from as early as 1970s indicate that the technology has been around since Soviet Union times[18–22]. This was confirmed by one of our interviewees who claimed that the first instance of LLL in Uzbekistan could be found as early as 1983. When the technology was re-introduced in the 1990s, it was used on a small scale in some pilot projects, and its success led to its adoption in many irrigation schemes across the country[9]. Initially, equipment was imported from other countries like Pakistan and India. In a step-by-step process, different parts of the LLL equipment have been 'localised' and adapted to local circumstances. First broader scrapers were manufactured to fit the larger tractors commonly used in Uzbekistan. Currently, most parts of the equipment can be manufactured locally, although the laser technology is still bought from outside the country. Several manufacturers operate nationally, with some selling imported foreign equipment. This sometimes provides problems with training of equipment and the availability of spare parts. LLL has been successfully applied in the cotton-growing regions of Uzbekistan, where the technology has helped to improve soil moisture management and increase crop yields. The government of Uzbekistan has recognised the importance of LLL. It has made significant investments in the technology, including establishing training centres and providing subsidies for LLL equipment.

By further scaling laser-assisted land levelling, Uzbekistan has two main aims. Firstly, the scaling of LLL is expected to help the country modernise its agricultural sector and improve the productivity and profitability of its farmers. This can positively impact the country's economy, food security, and overall development. However, LLL is especially important for crops that depend on irrigation. In Uzbekistan, these irrigated crops typically consist of cotton, (winter) wheat, rice, fruits and maise (corn). Since irrigated agriculture is vital in Uzbekistan, LLL has come to be considered a very promising technology to improve irrigation. The second aim of scaling LLL is to contribute to the environmental aspects: reduce water consumption and the associated fuel consumption of water pumps.

INNOVATION PROFILE OF COMPLEMENTARY INNOVATIONS

Innovations can only be used at scale with other innovations complementing their use. For instance, a machine can only achieve use at scale with complementary energy infrastructure, good practices for using it, etc. In the scaling assessment methodology, these rules, regulations and practices are called the complementary innovations. The idea is that, usually, 'regular' R&D programmes can improve the core innovations. However, by also looking at the necessary complementary innovations through the Innovation Package Profile, the bigger picture comes into view. Scaling an innovation might require much broader capabilities and sometimes the development of significant partnerships with other stakeholders, such as government, research, business or finance, or NGOs and civil society. As such, the "Scaling Readiness Innovation Package Profile" aims to improve an overview of the relevant context by helping to systematically identify other related innovations that complement or hinder the scaling of the LLL technology. In addition, it identifies the roles of other stakeholders, such as project managers, designers, developers, disseminators and use supporters in overcoming potential bottlenecks. LLL operates with several other technical and organisational innovations within Uzbekistan, such as precision agriculture, water management and irrigation technology, climate-smart agriculture, digitalisation, and rural infrastructure. Below a short description will be given of these complementary innovations:

INNOVATIVE WATER MANAGEMENT TECHNOLOGIES

Irrigation techniques are crucial, particularly in arid and semi-arid regions like Uzbekistan. Various irrigation techniques are employed to deliver water to crops efficiently, ensuring optimal growth and yield. In Uzbekistan, where water resources are limited, different irrigation methods have been developed and utilised to meet the diverse agricultural needs of the region. These water management options have different degrees of innovativeness. **Flood irrigation** is a traditional method used in Uzbekistan. It involves flooding the entire field with water, allowing it to infiltrate the soil and reach the crop roots.

Flood irrigation is commonly employed for crops like rice, wheat, and barley, which benefit from a waterlogged environment. However, this method can result in water wastage and uneven water distribution if not correctly managed. **Furrow Irrigation** is another traditional irrigation method used in Uzbekistan. This technique delivers water through small channels or furrows between crop rows. Gravity facilitates the flow of water, which infiltrates the soil and reaches the crop roots. Furrow irrigation is relatively simple and cost-effective, making it a widely used method for cultivating crops such as cotton and vegetables in Uzbekistan. **Double Furrow Irrigation** is a modification of furrow irrigation commonly practised in Uzbekistan. It involves using two parallel furrows on each planting row, allowing for better water distribution and increased water efficiency. This technique reduces water losses and ensures a more uniform distribution of water across the field. Double furrow irrigation is particularly suitable for crops with high water demands, such as maise and fruit orchards. **Drip Irrigation** is an efficient and precise irrigation method. It involves the controlled delivery of water directly to the plant's root zone through a network of drip lines or emitters. This technique conserves water by reducing evaporation and minimising runoff. Drip irrigation is well-suited for various crops, including fruit trees, vegetables, and vineyards, allowing for targeted water application and the efficient use of water resources. In general, the more expensive methods also give the highest returns in yields. However, initial investment costs often exceed the financial means of farmers in Uzbekistan. Laser-assisted land levelling is a tool that can often be used complementary to some of the innovative irrigation water management technologies or to upgrade existing irrigation techniques[23–28].

RURAL INFRASTRUCTURE AND IRRIGATION

Rural infrastructure such as roads, electricity, and telecommunications are critical for successful laser land levelling in Uzbekistan. Complementary investments in rural infrastructure can help farmers to access markets, reduce production costs, and increase the efficiency of laser levelling technology. Especially relevant in this regard is the infrastructure related to irrigation technology. Historically, the Soviet era played a significant role in shaping irrigation infrastructure in Uzbekistan. Large-scale irrigation projects were implemented, primarily focused on diverting water from major rivers such as the Amu Darya and Syr Darya to supply agricultural lands. Canals, channels, and reservoirs were constructed to facilitate water distribution across vast areas, enabling the expansion of cotton cultivation, a critical cash crop for the country's economy.

The present state of irrigation infrastructure in Uzbekistan is characterised by a combination of strengths and weaknesses. On the one hand, the country has an extensive network of canals, reservoirs, and pumping stations that provide water for irrigation. These infrastructure components have contributed to sustaining agricultural production and supporting livelihoods in rural areas. On the other hand, however, the ageing infrastructure requires rehabilitation and modernisation to improve water delivery efficiency, reduce losses, and ensure equitable distribution. Many canals suffer from leaks, inadequate lining, and insufficient maintenance, leading to water losses and inefficiencies. The mismatch between water supply and demand, especially during peak periods, poses further challenges to water management and distribution. The implementation of LLL fits in the ongoing efforts of the government to implement policies and programs to promote water-saving technologies and reduce water consumption in agriculture[24–34].

AN ENABLING POLICY ENVIRONMENT

New technologies and innovations also require implementing new government policies and tools to support the development and implementation of these new technologies. Sometimes this requires relatively simple changes, such as the adoption of funding to support R&D efforts and subsidise the new technology's procurement. However, sometimes it also requires a fundamental look at some of the existing policy practices and how they shape opportunities and barriers for the diffusion of a new technology. Below, we will describe several factors related to land ownership and governance structures in Uzbekistan that influence the policy environment for LLL.

In Uzbekistan, the organisation of land ownership and agricultural production follows certain principles and practices. **A farm** is a legal entity engaged in agricultural production on state land based on a lease agreement. Lease contracts can span up to 50 years and give farmers the right to cultivate and manage the land, subject to specific regulations and obligations. Farmland size ranges based on production specialisation: cotton and wheat farms start with 30 ha, farms specialising in vegetables are at least 3 ha, and orchards and horticulture-focused farms have a minimum of 10 ha. Farms or other agricultural enterprises can sublease parts of their agricultural land to dekhans for up to one year for intermediate sowing of crops.

A dekhkan farm (0.06-1 ha) is a farm that grows and sells agricultural products based on the personal labour of members on a plot provided to the head of a dekhkan farm based on a lifetime inherited ownership or lease (sublease). Dekhans may hire others on temporary or seasonal employment contracts to perform specific work. Tomorqa plots are smaller (approximately 0.25 hectares) and are small private land plots attached to the house and owned by households[35].

Since independence in 1991, the government has launched several rounds of farm restructuring, see Table 3. After 2008, a process of land consolidation took place in Uzbekistan, resulting in the redistribution of land into larger plots. This consolidation aimed to optimise land use and improve agricultural productivity. However, as a consequence, approximately three-quarters of farmers experienced land loss or changes in their landholdings. Land consolidation and redistribution had significant implications for the farming community, requiring production practices and land management adjustments.

Table 3: Overview of land reforms in Uzbekistan since independence

1992 – 1997	1998 – 2002	2003 – 2008	2008/09 – 2015	2016 – present
Decollectivisation of state farms	Partial break-up and downsizing of producers	Complete breakup and downsizing of producers	Consolidation of producers	Production specialisation
Transformation of sovkhozes into kolkhozes	Transformation of kolkhozy into shirkatlar; partial fragmentation of shirkatlar into private farms	Complete fragmentation of shirkatlar into private farms	Private farms merged into larger units via reallocating land from farms with size 530 ha to larger ones	Fragmentation and optimisation of production

Source: World Bank, 2019. Djanibekov et al. 2012

Agricultural norms and regulations play a significant role in shaping agricultural practices in Uzbekistan. Uzbekistan is generally organised top-down with little public participation, accountability, and transparency upwards [26]. The government establishes norms to regulate cropping patterns, the use of inputs, and other agricultural practices. Compliance with these norms is monitored and enforced to ensure conformity and consistency in agricultural production. Farmers are expected to adhere to these norms and may face penalties or consequences for non-compliance. For instance, if farmers cannot meet a minimum production level compared to the average yield of similar farms for three subsequent years, they risk losing their lease on the land.

Current policy objectives in Uzbekistan are related to the modernisation of the agricultural sector, productivity improvement and how to balance these against sustainability issues and farmer welfare and livelihoods. Given the importance of irrigated agriculture within Uzbekistan, adopting LLL fits well with these overall government objectives. The broader institutional framework in which LLL operates consists of several organisations responsible for policy development, implementation, and monitoring. In Uzbekistan, the Ministry of Agriculture, the Ministry of Water Resources, and other related government agencies for water management play a central role in formulating and implementing agricultural policies. These institutions oversee the agricultural sector, provide support services, and monitor policy outcomes. They also historically have their own research institutes [38]. Uzbekistan is generally organised in a top-down way that provides special attention to large-scale producers and vertically integrated 'clusters' [39, 40]. The current position of extension services is somewhat scattered and not linked around the whole system concept [41].

CLIMATE-SMART AGRICULTURE

Climate change is a growing concern for farmers in Uzbekistan [42–44]. Complementary climate-smart agricultural (CSA) practices can help to mitigate its impact [45]. In general, Climate-Smart Agriculture (CSA) is an approach that seeks to address the challenges of climate change in agriculture while ensuring sustainable food production, adaptation, and mitigation. CSA is guided by three interconnected principles:

1. **Productivity:** CSA aims to enhance agricultural productivity and income, ensuring food security and improving rural livelihoods. It promotes practices and technologies that optimise yields, resource use efficiency, and farm productivity in a sustainable manner. By adopting improved farming techniques, using quality inputs, and implementing effective management strategies, farmers can achieve higher productivity and economic returns.
2. **Adaptation:** CSA focuses on building the resilience of agricultural systems to the impacts of climate change. It emphasises adopting climate-resilient practices that enable farmers to cope with changing climatic conditions, variability, and extreme events. Adaptation measures may include crop diversification, improved water management, conservation agriculture, agroforestry, and other strategies tailored to local contexts.
3. **Mitigation:** CSA recognises the role of agriculture in contributing to greenhouse gas emissions and aims to reduce its carbon footprint. It promotes practices that mitigate greenhouse gas emissions while maintaining or enhancing productivity. These may include agroforestry, precision farming, improved livestock management, organic agriculture, and the use of renewable energy. By adopting low-carbon agricultural practices, CSA contributes to climate change mitigation efforts.

In addition to these three principles, CSA is guided by cross-cutting principles of sustainability, resilience, knowledge, and innovation. CSA emphasises the long-term sustainability of agricultural systems, considering ecological, social, and economic aspects. It promotes practices that conserve natural resources, protect biodiversity, enhance soil health, and promote equitable and inclusive development. At the same time, CSA aims to build the resilience of agricultural systems and communities, ensuring their ability to cope with shocks and stresses, including those related to climate change. It promotes practices that enhance adaptive capacity, strengthen livelihoods, and empower farmers to withstand and recover from climate-related challenges. Finally, CSA recognises the importance of knowledge, information, and innovation in driving agricultural transformation. It promotes the adoption of climate-smart technologies, capacity building, and knowledge-sharing platforms to facilitate learning, innovation, and the uptake of best practices.

Overall, CSA principles can be combined well with the adoption of LLL, and it is expected that they can promote sustainable and climate-smart land management practices, contributing to the overall sustainability and productivity of agricultural systems in Uzbekistan.

DIGITAL PLATFORMS, ICT AND PHONE-BASED APPS

Information and Communication Technology (ICT) and digital platforms have revolutionised various industries, and the agricultural sector is no exception. The integration of ICT solutions and digital platforms in agriculture can bring numerous advantages and have the potential to transform traditional farming practices into modern, efficient, and sustainable systems [46, 47]. For instance, ICT and digital platforms provide farmers with easy access to information and knowledge related to agricultural practices, crop management, pest control, weather patterns, market prices, and more. Access to real-time data and expert advice empowers farmers to adopt best practices, enhance their skills, and stay updated on the latest advancements in the agricultural domain. Farmers can leverage digital solutions for farm management, including automated irrigation systems, precision agriculture technologies, and remote sensing techniques. These technologies enable accurate monitoring and control of factors such as water usage, fertilisation, and crop health, ensuring optimal resource utilisation and minimising risks associated with climate variability, pests, and diseases. The integration of ICT promotes more precise and targeted interventions, resulting in higher crop yields and reduced input costs. Finally, ICT and digital platforms encourage knowledge sharing, collaboration, and peer-to-peer learning within the agricultural community. Farmers can connect with experts, extension services, and fellow farmers through online forums, social networks, and digital communities. ICT-based agricultural extension services encompass various tools such as SMS and other messaging platforms and audio and video elements. This exchange of knowledge, experiences, and best practices fosters innovation, encourages continuous learning, and supports the adoption of sustainable agricultural practices. Digital platforms also facilitate partnerships among various stakeholders, including researchers, policymakers, and industry players, promoting collaborative efforts towards agricultural development. Compared to traditional approaches, using ICT (Information and Communication Technology) in agricultural extension services offers several advantages. It reduces costs associated with service delivery and travel while ensuring more consistent and timely support for agricultural producers [48, 49]. Digital platforms, irrigation and LLL can reinforce each other by providing up-to-date information about weather conditions and irrigation levels [50]. In addition, digital apps and smartphones can also be set up as a tool for extension services to provide advisory services to farmers, for instance, through instruction videos, chatbots and other digital helplines. In recent years, the government of Uzbekistan has launched an ambitious and large-scale sectoral ICT development strategy (Smart Agriculture) that also promotes the improvement of digital services for the agriculture sector [38].

PART B

SCALING READINESS ASSESSMENT OF LASER LEVELLING IN UZBEKISTAN

INTRODUCTION TO SCALING READINESS ASSESSMENT

The Scaling Readiness assessment provides a detailed account of the core elements of LLL in Uzbekistan and the complementary innovations that are critical for the impact at scale potential. This identification helps highlight the critical bottlenecks that hinder the scaling of the core innovation.

Before we get into the analysis itself, it is important to introduce the scaling readiness indicator in more detail. The Scaling Readiness of an innovation is measured along two axes to assess the impact potential of the LLL in Uzbekistan: the Innovation Readiness Level and the Use Level. The Innovation Readiness Level (IRL) measures how mature and practical an innovation is in achieving its intended objectives. It assesses an innovation's functionality and development stage, ranging from 0 (where the innovation is only an idea) to 9 (indicating a proven innovation with clear evidence of its value and impact on livelihoods and profits). Research and Development projects contribute to increasing Innovation Readiness Levels by improving the design, validating the innovations in controlled and uncontrolled conditions, and enhancing their practicality. The Innovation Use Level (UL) refers to the extent to which an innovation is being used at scale. It considers questions like who uses the innovation and the magnitude of its use. The UL scale also ranges from 0 (indicating no usage of the innovation, which an intervention aims to increase) to 9 (suggesting widespread use among users who are not involved in innovation design, development, or dissemination processes). The UL can be considered an advanced measure for the adoption of innovations, combining adoption with the support provided by projects and considering a diverse range of users. It provides a more comprehensive estimate of the potential use of an innovation at scale. Table 4 briefly describes the nine levels of Innovation Readiness and Innovation Use. More information and a more detailed description of the different Readiness and Use Levels can be found in the Scaling Readiness manual [2].

The different elements of the core and the complementary innovations are individually assessed. The Scaling Readiness is displayed in a graph where the Use Level is indicated on the horizontal axis, and the (technical) Innovation Readiness is displayed on the vertical axis.

Concerning the assessment itself, a couple of important remarks must be made. First of all, when assessing the innovation readiness, we also incorporate some of the contextual elements of Uzbekistan. That means that even if an innovation has found an application outside of Uzbekistan and is well established, even commercially, in agricultural settings in highly modern farming systems, we can still decide that the Innovation Readiness within the context of Uzbekistan still needs to be fully developed. Arguments to lower the Innovation Readiness score could, for instance, be related to the accessibility and adaptability of the technology to the specific contextual factors of agriculture in Uzbekistan. Such shortcomings would present themselves in the form of (very) high prices that would put an innovation out of reach of most farmers in Uzbekistan.

Table 4: Overview of Readiness and Use Levels

Level	Innovation Readiness	Innovation Use
1	Hypothesis: A cognitively validated idea about a novelty's ability to solve a problem	Intervention Core Team: The novelty is only used by the intervention team
2	Basic Model (unproven): Desktop research on the hypotheses using existing conceptual/theoretical evidence	Partners (rare): The novelty has some use by the intervention partners
3	Basic Model (proven) Conceptual/ theoretical validated set of interrelated hypotheses	Partners (common): The novelty is commonly used by the intervention partners
4	Application Model (unproven): Desktop research on the basic model's ability to solve a problem using existing applied evidence	Unconnected designers and developers (rare): The novelty has some use by designers and developers who are not directly involved in the intervention
5	Application Model (proven): Validated basic model using applied evidence	Designers and developers (common): The novelty is commonly used by designers and developers who are not directly involved in the intervention
6	Application (unproven): Experimental research on the application model's ability to solve a problem in the controlled conditions	Delivery and use support stakeholders (rare): The novelty has some use by delivery and use support stakeholders who are not directly involved in the intervention

Level	Innovation Readiness	Innovation Use
7	Application (proven): A validated application using experimental evidence	Delivery and use support (common)
8	Innovation (unproven: Testing the capacity of the application to generate value by solving a problem in a specific uncontrolled context	The novelty is commonly accepted by delivery and use support stakeholders who are not directly involved in the intervention.
9	Innovation (proven): A validated application using evidence on the value or benefit	End-users (pioneers): The novelty has some use by the end or final users who are not involved in the intervention

Source: adapted from [2]

The second important element to consider when reading this part is understanding the concept of the 'law of the minimum' that also applies to scaling processes. The law of the minimum implies that a core innovation cannot be scaled successfully unless all the elements within the complete innovation package perform above a certain minimum level. The idea is that even if an innovation itself is well-developed and ready for scaling, its successful adoption at scale is contingent on a formal or informal knowledge system through which its advantages can reach end users. Furthermore, the Law of the Minimum stresses the interdependence of core and complementary innovations. The readiness of the core innovation alone is insufficient if complementary innovations, such as the extension system and market promotion, are lacking. Finally, the law of the minimum has implications for our grading. Sometimes we assess a TRL, or UL somewhere in between two levels. In such a case, we 'round down' and assign the lowest level.

Finally, Scaling Readiness uses rigorous scientific methods and tools for data collection and analysis to formulate a scaling strategy. This makes Scaling Readiness perhaps more laborious than other approaches, but it has the advantage of allowing projects' advances in Scaling Readiness to be monitored credibly. In addition, it enables the scaling scientists and/or those responsible for a more extensive portfolio of projects to conduct comparative analysis and aggregate findings, lessons, and Scaling Readiness assessments across projects. This means that the assessments and scores of the various elements of core innovation and complementary innovations introduced in section A of this report have to be grounded, as much as possible, in verifiable scientific and other reliable sources. In addition, we have interviewed several regional experts on laser-assisted land levelling in Uzbekistan to provide us with their opinions on specific aspects of LLL to complement these data sources. To make the processes visible, we will, as much as possible, make arguments about how and why we give a specific score.

In summary, this part of the report presents:

- The readiness and use scores of novel components of the LLL innovations that are necessary to achieve a positive impact from using LLL at scale.
- The readiness and use scores of the accompanying innovations necessary for the LLL technology to achieve a positive impact from using LLL at scale in Uzbekistan.
- The readiness and use scores are presented with the most important arguments and data sources on why these scores were given.

SCALING READINESS ASSESSMENT OF LLL CORE ELEMENTS

Assessment of readiness levels

To facilitate the assessment of the scaling readiness, the key components of laser-assisted land levelling (LLL) technology have been grouped into three main categories: a) the tractor, b) the scraper, and c) the different electronic parts like the lasers, sensors, control panel and so on. See part A for a more extensive analysis of the key features of the LLL system. Each of these categories plays a crucial role in the overall functioning and effectiveness of LLL. The advantage of making these subgroups is that they can be combined into different forms of land levellers. The combination of tractors and scrapers is a combination that makes a 'regular' land leveller. Combining all three subgroups: tractor, scraper, and electronics makes a Laser-assisted Land Leveller. Below we'll assess the Technology Readiness Level of each subgroup using the provided TRL ranking system.

Tractor: The tractor is an essential component of the LLL system, providing the power and mobility required for land levelling operations. Although a leveller, strictly speaking, doesn't need a tractor, this is the most common way for the LLL technology to be applied. The tractor has been around for ages and is one of the main technologies that farmers worldwide employ. Although new features will also be introduced in the tractor systems of the future, the basic technology itself has been developed into a so-called 'dominant design' [51]. The tractors used for LLL in Uzbekistan will also have to incorporate some advanced features, such as hydraulic control systems and automatic guidance, contributing to precise land levelling outcomes. However, a commercial market has also been established for these types of tractors, both internationally and at the national level of Uzbekistan. Different types of tractors, including chopping, transport and mini tractors, are available, and as such, there is no issue of accessibility or adaptability of tractors for the situation of Uzbekistan. Therefore, this element of the LLL technology is assessed at the highest level with an **IRL-9**.

Scraper and bucket systems: The scraper unit is another critical component of LLL, responsible for physically moving and levelling the soil. The scrapers used in LLL systems in Uzbekistan have initially been imported, but over time modifications have been made to adapt these scrapers to the working conditions within Uzbekistan. For instance, initially, LLL systems imported from India and Pakistan were relatively small, especially considering the large field plots in Uzbek agriculture. This sometimes made the scraper systems and (large-scale) tractors used in Uzbekistan incompatible. A similar problem occurs for scrapers developed for these large-scale plots: they are too big for use on some of the smaller fields of the subsistence farmers. Some of these compatibility issues remain to this day, which has also been mentioned in the interviews as a limiting factor for even the adoption of regular land levelling systems. For this reason, we give an **IRL score of 8** to indicate that there is still room for improvement, even for regular land levellers.

Electronics: The electronics component of LLL encompasses the laser transmitter, receiver, and control systems responsible for guiding the land levelling process. These electronic systems have been extensively tested, validated, and proven to operate effectively in the field. The laser transmitter emits a rapidly rotating laser beam parallel to the required field plane, which is accurately detected by the receiver fitted to the tractor. The signal is converted into precise cut and fill level adjustments, ensuring accurate and automated land levelling. Like the other technical components of the LLL system, the electronics component has shown its reliability and competitiveness within a robust international market. However, this technology is manufactured outside of Uzbekistan and needs to be imported, which increases the price of a component that is already relatively expensive within the context of the agricultural sector in Uzbekistan. In addition, the fact that the electronic parts and the lasers have to be imported often also means that documentation and manuals are not available in Uzbek (or Russian), and this can add to the difficulty for local farmers to buy and successfully operate such a system. They often still have to rely on advice from extension services or more experienced farmers. For this, we grade this part of the LLL system at **IR-L 7**.

In summary, the key components of laser-assisted land levelling technology in Uzbekistan can be grouped into three categories: the tractor, the scraper, and the electronics. These three subgroups all receive relatively high marks for their innovation readiness: they have all demonstrated high performance in a commercial international setting. As such, these technologies reflect the proven nature and effectiveness of the LLL technology, providing confidence in its operational capabilities and scalability in an international context. However, based on the national context of Uzbekistan and issues of accessibility (reflected in price) and adaptability, we subtracted some points from the Innovation Readiness Score for the electronic parts and the scraper/bucket systems

Assessment of LLL's use levels

In this section, we will provide arguments about the dissemination of the LLL technology within Uzbekistan. Again, we will use the three subgroups of tractors, scrapers and electronics to make this assessment. However, instead of assessing these subgroups individually, we will divide them into 'regular land levellers' and laser-assisted land levellers. Regular land levellers consist of two components: a tractor and a scraper. Laser-assisted levellers comprise all three elements: tractor, scraper and electronic parts such as the laser and sensor. The reason is that it is no use to assess the use level of these parts individually. No farmer will buy the electronic parts associated with LLL unless they already have access to a tractor and a scraper.

Table 5 provides an overview of the number of tractors and land levellers, both laser-assisted and regular, in Uzbekistan. The 'regular land levellers' consists of a scraper system and a tractor without the electronic parts related to the laser. The table shows a considerable number of laser levellers across the country. However, consultants estimated the proportion of laser-assisted land levellers to regular levellers to be 1/5, or 20 %, of the total number of land levellers (personal communication). In addition, Table 5 shows that some regions have a limited uptake of LLL despite having access to tractors. The use of laser-assisted land levellers was also strongly divided across Uzbekistan in 2021, see Figure 4.

Table 5: Total number of tractors and land-levellers in use in Uzbekistan

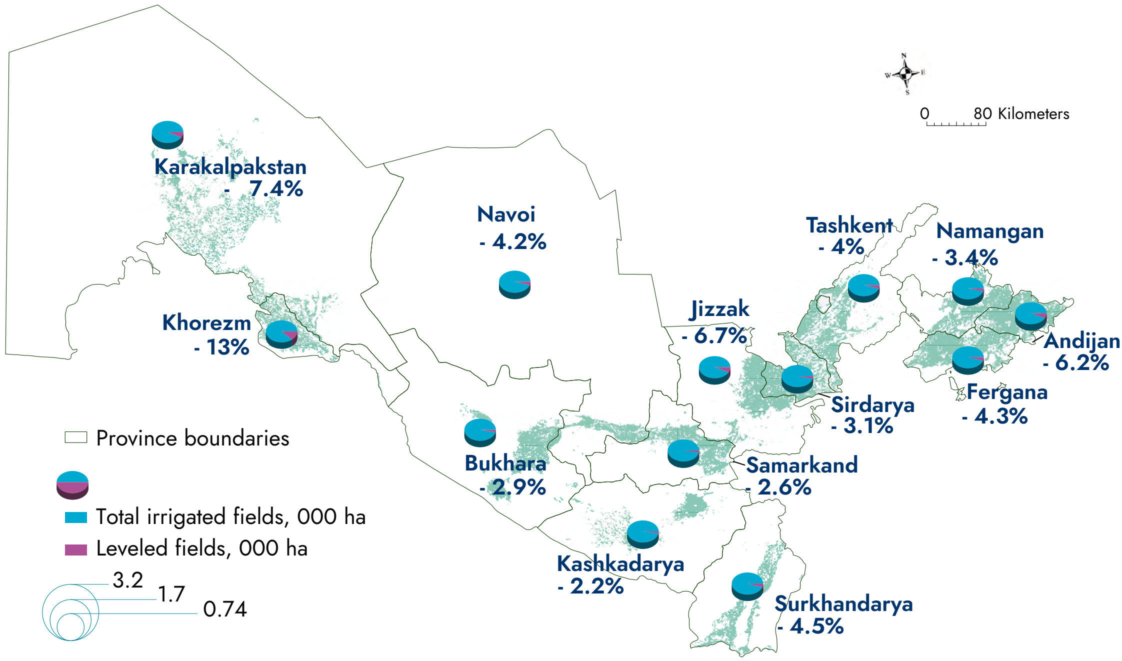
	Number of driving tractors	Number of mini tractors	Number of land levellers (both regular and laser-assisted)
Karakalpakstan	719	36	126
Andijan	600	83	194
Bukhara	690	52	120
Jizzakh	480	30	127
Kashkadarya	938	62	79
Navoi	337	24	71
Namangan	452	125	95
Samarkand	489	231	59
Surkhandarya	470	70	87
Syr Darya	449	19	136
Tashkent	887	207	28
Ferghana	673	226	325
Khorezm	892	25	838
Total	**8,076**	**1,190**	**2,285**

Source: Open data portal [1], April 2023

Based on these data and the interviews, we assign the use level for tractors at UL-9 and the use level of regular land levellers at UL-8. The idea here is that the same technical adaptability issues also influence the use level negatively. Only some farmers who would like to use a land leveller have access to it. Finally, the electronic components that make the system into an LLL are still the least in use. In some provinces, LLL has taken a foothold. However, in other provinces, such as Navoi, the use of laser-assisted land levelling is still limited. There are multiple mentions of traditional land levellers in legal documents. But it wasn't until 2018 that the first official government decree mentioned laser-assisted land leveling (LLL). Additionally, state support for the adoption of LLL was initially documented in 2020 [52, 53]. For this reason, we assign the use level of LLL in Uzbekistan a UL-6.

1 Source: Open data portal1, April 2023

Figure 4: Map of Uzbekistan with laser levelled land area per province

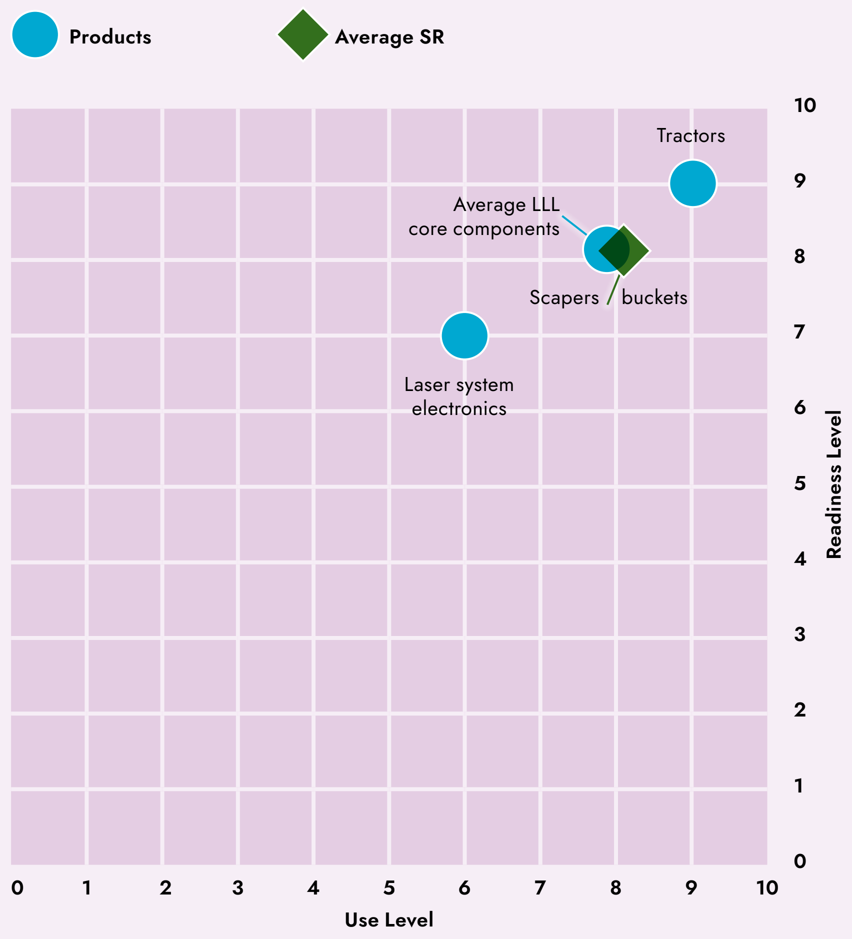


source: Calculations based on data from the Ministry of Agriculture

SUMMARY OF SCALING READINESS OF THE CORE ELEMENTS OF LLL

The combination of the innovation readiness and the use levels gives the final scaling readiness number, see Figure 5. The formula to calculate the Average Scaling Readiness is to multiply the average Innovation Readiness Level by the average Use Level. The average IRL for all three core components is 8, and the Use Level average is 7.67. This gives an overall scaling score of 61.3. This can be considered a relatively high score for the overall scaling readiness (given that the maximum score for both indicators is 9. It means that LLL consists of several mature technologies that have proven themselves in commercial settings outside Uzbekistan. The first steps have also been made for the scaling inside Uzbekistan. Concerning the Use Level: it seems that the National Agricultural Research System (consisting of universities, research institutes and state-sponsored extension services) is well aware of the advantages of Laser-assisted land levelling and is also ready to promote its use among farmers. According to the data, some early adopters have started applying LLL. However, the average number of fields where LLL has been applied varies greatly per province; for some provinces, the laser levelled area is still comparatively low. Overall, sales data of regular versus laser-assisted levellers from the last five years indicate a shift towards laser land levellers, and we take this as an early sign that the scaling phase is moving from pre-development towards acceleration. In the next section we will investigate the accompanying innovations that can facilitate or hinder the further scaling of LLLs

Figure 5: Scaling Readiness plot for laser-assisted land levelling



SCALING READINESS ASSESSMENT OF COMPLEMENTARY INNOVATIONS

In this section, we will assess the readiness and use levels of the accompanying technical and organisational innovations that can facilitate or hinder the scaling of the LLL technology in Uzbekistan. In part A, the following complementary innovations have been identified: 1) irrigation infrastructure, 2) innovative water management approaches, 3) climate-smart agriculture, 4) digital platforms and apps, and 5) an enabling policy environment. Below, we will discuss the readiness and use levels for these complementary innovations.

IRRIGATION INFRASTRUCTURE

Historically, the Soviet era played a significant role in shaping irrigation infrastructure in Uzbekistan. Large-scale irrigation projects were implemented, primarily focused on diverting water from major rivers such as the Amu Darya and Syr Darya to supply agricultural lands. Canals, channels, and reservoirs were constructed to facilitate water distribution across vast areas, enabling the expansion of cotton cultivation, a critical cash crop for the country's economy. Currently, the country has over 4 million hectares of irrigated land, of which around 2.4 million hectares are irrigated using electrical pumping stations [54]. Electricity bill subsidies for those pumping stations represent a significant share of public expenditure to the sector, 0.6 % of GDP [54]. The irrigation infrastructure is outdated and needs substantial investment. Uzbekistan's average annual water consumption is 51 km^3, of which about 46.8 km^3 or 90 % is used in rural households.[1]

The present state of irrigation infrastructure in Uzbekistan is thus characterised by a combination of strengths and weaknesses. On the one hand, the country has an extensive network of canals, reservoirs, and pumping stations that provide water for irrigation. These infrastructure components have contributed to

1 SSC, https://nsdg.stat.uz [accessed July 2023]

sustaining agricultural production and supporting livelihoods in rural areas. On the other hand, however, the ageing infrastructure requires rehabilitation and modernisation to improve water delivery efficiency, reduce losses, and ensure equitable distribution. Many canals suffer from leaks, inadequate lining, and insufficient maintenance, leading to water losses and inefficiencies. The mismatch between water supply and demand, especially during peak periods, poses further challenges to water management and distribution. All in all, the implementation of LLL fits in the ongoing efforts of the government to implement policies and programs to promote water-saving technologies and reduce water consumption in agriculture. Overall, we assess the Use Level of Rural infrastructure as relatively high: in large parts of Uzbekistan, farmers rely on it – **UL 9**. At the same time, the technological readiness level has steadily decreased over time. The irrigation infrastructure's design focused on the large agricultural enterprises of the Soviet Era. It doesn't serve the new situation well. Although there are plans to modernise and update the system, many of these ideas are still only in the planning stage: **IRL – 6**.

INNOVATIVE WATER MANAGEMENT APPROACHES

Irrigation techniques are of crucial importance for the agricultural sector in Uzbekistan. Smart irrigation technologies can help farmers in Uzbekistan to optimise their water usage as climate change and growing soil salinity are increasingly threatening the existing irrigation infrastructure in Uzbekistan. LLL is seen as a promising technology to help reduce the amount of irrigation water needed [55, 56]. As such, it is important to note that from the perspective of innovative water management technologies, the scaling of LLL is not the goal; it is a method to make irrigation more efficient.

In July 2023, the Minister of the Ministry of Water Resources (MoWR) stated that out of the country's total irrigated area of 4.3 million hectares, water-saving technologies had been implemented on 1.2 million hectares (28 %). Drip irrigation covers 473.5 thousand hectares, sprinkling irrigation covers 44.7 thousand hectares, discrete irrigation covers 18 thousand hectares, laser levelling covers 569 thousand hectares, and other water-saving technologies cover 133.9 thousand hectares.[2] However, there is currently no proper system for evaluating the impact of the water-saving technology adoption program. The government's assessment

2 Minister of MoWR statement, July 2023, https://www.gazeta.uz/oz/2023/07/06/water/ [accessed July 2023]

primarily focuses on verifying whether the subsidies for adopting water-related innovations were used for their intended purpose. As a result, the given numbers are likely based on the total area where the technology has been adopted, with limited consideration given to its efficiency and effectiveness.

Researchers conducted a study to explore the practical applications of laser-guided land levelling for cotton, drip irrigation for tomatoes, and improved furrow irrigation practices such as surge flow, double furrow, alternate dry furrow, and short furrow for cotton cultivation[57]. Their findings reveal an interesting relationship between the potential for water use improvement and the financial feasibility of different water-saving options. Essentially, the more efficient a technology is in conserving water, the higher the investment required. The researchers concluded that considering most farmers have limited financial resources, it is more practical to focus on low-cost approaches. Among these, the short and double flow techniques and the alternate dry furrow system show great promise in irrigated cotton production. These methods offer significant benefits with minimal implementation costs and reduced water usage. Although drip irrigation is considered technically the most advanced and offers the highest increases in yields, it also has some disadvantages. Although drip irrigation and LLL are very compatible, their respective costs are so high that no farmer will adopt both technologies. An advantage of LLL is that its cost can be divided between different farmers. Laser-assisted land levelling services have already become part of some of the extension services: farmers pay a fixed rate for the use of the equipment. In contrast, drip irrigation is typically purchased and used by a single farmer. Drip irrigation is beyond the financial means of the average farmer due to income constraints posed by the state order system[16].

Based on these sources, we assess the Innovation readiness score of water-saving techniques to be well developed and implemented by a range of end-users, especially within the international context. However, many innovative water management technologies still need to be implemented in Uzbekistan. The technological readiness of these water management technologies is assessed at **IRL-7**. The expensive but potentially also most rewarding systems, such as drip irrigation, have only been implemented by a tiny group of farmers with the financial means to do so. An overview of the advantages, disadvantages and practical considerations of implementing innovative water management technologies still seems to be missing from (parts) of the government system: **UL – 6**.

CLIMATE-SMART AGRICULTURE

Climate-Smart Agriculture (CSA) is an approach that seeks to address the challenges of climate change in agriculture while ensuring sustainable food production, adaptation, and mitigation. CSA is guided by three interconnected principles: 1) **Productivity:** CSA aims to enhance agricultural productivity and income, ensuring food security and improving rural livelihoods; 2) **Adaptation:** CSA focuses on building the resilience of agricultural systems to the impacts of climate change. It emphasises adopting climate-resilient practices that enable farmers to cope with changing climatic conditions, variability, and extreme events; 3) **Mitigation:** CSA recognises the role of agriculture in contributing to greenhouse gas emissions and aims to reduce its carbon footprint. It promotes practices that mitigate greenhouse gas emissions while maintaining or enhancing productivity.

Within the context of Uzbekistan, the focus on increasing agricultural productivity makes CSA an excellent fit for existing agricultural policy initiatives. In addition, the adaptation and mitigation strategies can fit well within the context of Uzbekistan as well. Although it is difficult to assess the potential impacts of climate change on central Asia, it has been argued that even small changes can already have significant consequences, particularly for people experiencing poverty [43]. Furthermore, water pumps connected to agricultural irrigation are an important source of greenhouse gas emissions. Making irrigation more efficient by implementing LLL, therefore, also contributes to reducing the energy use of these pumps. Integrating CSA principles with LLL can promote sustainable and climate-smart land management practices, contributing to the overall sustainability and productivity of agricultural systems in Uzbekistan.

However, climate-smart agriculture is still a relatively recent idea that only has come up in the scientific literature since its introduction by the FAO in 2010 [58]. At this point, a universal approach to integrating the three different elements and measuring them is still missing [59]. One of the reasons is no doubt that CSA is essentially context-specific, so it needs to be adapted to local circumstances. Although there is research done on CSA, there is not yet a fully elaborated approach that can easily be implemented in Uzbekistan. Recently a UNDP project has been started to work on CSA in Uzbekistan called ***"Supporting an inclusive transition to a "green" economy in the Agri-food sector and development of a "climate-smart" Uzbek Agriculture Knowledge***

and Innovation System".[3] This is an important start, but since the project is ongoing and further steps need to be developed, we assess the Innovation Readiness Level at a 4 and the Use Level of CSA at 5, indicating that it is still an innovation being discussed and developed chiefly by researchers.

DIGITAL PLATFORMS, ICT TOOLS AND PHONE-BASED APPS

Uzbekistan has embarked on an ambitious and extensive ICT development strategy known as Digital Uzbekistan-2030, aimed at fostering various ICT advancements throughout the country. The strategy provides for the implementation of two programs: the digitalisation of regions and the digitalisation of industries. Among these industries, the agriculture sector stands as a key beneficiary, as the strategy aims to enhance digital services in rural areas and small towns [38]. Following the adoption of the Strategy Digital Uzbekistan, sectoral digitalisation strategy "Smart Agriculture" was adopted[60].

The Ministry of Agriculture (MoA) in Uzbekistan has made efforts to integrate various databases and digitalize agricultural information. This includes the integration of soil information related to arable land in the Tashkent region into a geoportal, which incorporates data on mechanics, salinity, leaching, petrification, underground water, and other soil parameters. Additionally, the ministry conducted analyses on important soil parameters such as potassium, humus, and phosphorus, creating a comprehensive database. Geobotanical research results were also integrated into the MoA's geoinformation system based on the ArcGIS software, providing information on nutritious plants [6].

To support these digital initiatives, the MoA established its own digitalisation centre, which has developed and maintained 21 digital products over a span of two years.[4] However, concerns have been raised regarding the speed of development without sufficient preparatory research or analysis on budget, sustainability, and maintenance of the digital platforms. Consultants have pointed out that the digital project portfolio appears to be focused on ICT and institutional aspects, lacking clarity on addressing specific agri-food sector problems and implementation strategies. For instance, the integration of the Agrosubsidy platform of the Ministry of Agriculture and the UzASBO

3 https://www.undp.org/uzbekistan/projects/supporting-inclusive-transition-green-economy-agri-food-sector-and-development-climate-smart-uzbek-agriculture-knowledge-and [accessed July 2023]

4 https://digitagro.uz/ru/

software package (an automated accounting and reporting system) of the Ministry of Finance, has not yet been implemented. The Centre for Agricultural Machinery Certification and Testing, responsible for maintaining the platform for certification of imported agricultural machinery, does not appear to be operational.[5] Similarly, although the agricultural marketplace E-Agrosavdo, developed by the MoA's digitalisation centre, has been launched, its website statistics are rather poor.[6]

Overall, the government's digitalisation agenda in agriculture is perceived more as a top-down extension of policies in digital format, rather than a service-oriented information delivery mechanism. These observations were highlighted in a communication with a consultant of EU ASK Facility project, pointing out the need for further attention to address implementation challenges, sustainability, revenue generation, and effective service delivery within the digitalisation efforts in the agricultural sector.

Still, the potential for digital platforms and phone-based ICT tools in Uzbekistan are good. Approximately 65 % of farmers uses a smart phone, and almost 27 % use a laptop or a desktop for farm business [61]. Based on these numbers we assess the Innovation Readiness of such digital platforms and ICT applications in agriculture to be of a high level: **IRL-8**. However, the use level within Uzbekistan is also a bit lower. For instance, AKIS, the digital agenda is driven top down by the government, thus they are still not perceived as a service and information delivery mechanism by farmers and therefore we assess **the Use Level at 6**.

AN ENABLING POLICY ENVIRONMENT

New innovations also need new institutions: new rules and regulations that guide the scaling of the innovation. The more radical and disruptive an innovation is, the more new policies it will require.

The policy environment surrounding laser-assisted land levelling in Uzbekistan can be characterized as a mix of enabling and disabling factors. While there are certain aspects that support the adoption of LLL, such as high levels of financial support, there are also challenges that hinder its widespread

5 https://reestr.agro.uz/ru
6 https://agroetp.agro.uz

implementation, primarily related to land tenure insecurity and the top-down policy-making approach prevalent in Uzbekistan. We identify four different factors under the policy environment: 1) subsidies, 2) machine tractor parks, 3) the land tenure system and 4) extension and capacity building organisations.

Subsidies

On the positive side, Uzbekistan's government has demonstrated a commitment to modernising and improving the agricultural sector, including the promotion of precision farming techniques like LLL. Financial support programme, such as subsidies and loans, have been introduced to incentivise farmers to adopt advanced technologies like LLL. These financial resources can significantly alleviate the initial investment burden associated with acquiring LLL equipment, making it more accessible to farmers. In recent years, subsidies have shifted from farmers towards retailers and manufacturers in the hope of localising production more and more in Uzbekistan. At the moment a pilot project (in Karakalpakstan) is running that offers direct subsidies for farmers who engage in laser land levelling. Depending on the evaluation of this pilot project, farmers could be eligible for direct subsidies again. But this is not yet the case (in July 2023). Overall, we rate the readiness of the subsidies at an **IR-7, and the Use Level UL at a 5**.

Land tenure

The insecure land tenure system in Uzbekistan poses a significant challenge to the widespread adoption of LLL. In Uzbekistan, agricultural land tenure insecurity has been historically linked to the state's production and procurement targets for cotton and wheat. Failure to meet these targets resulted in the nullification of land lease agreements by regional and district governors. Although the situation has improved with the abolishment of the state procurement system for cotton and wheat in respectively 2022 and 2023, the uncertainty persists among agricultural land users due to various legal possibilities outlined in the Land Code that still can result in the termination of land leases [35, 62]. These legal provisions leave farmers vulnerable in front of institutions and local authorities. The government adopted a decree guaranteeing against farm restructuring/optimisation of lands where water-saving irrigation systems have been introduced for at least 5 years [63]. However, it is yet to be tested whether such promises are felt by the farmers.

Farmers' concerns about their land rights and tenure security make them hesitant to invest in long-term agricultural technologies like LLL. The lack of clear and stable land ownership or leasehold arrangements creates uncertainties and limits the willingness of farmers to make substantial investments that require extended periods to recoup the costs. Household plots with high tenure security provides with more incentives for the adoption of sustainable land management practices such as LLL as it allows for fuller internalisation of often long-term benefits of sustainable land management[64]. On paper, land tenure is well organised, in practice farmers still feel the effects of historical land reforms and don't yet trust the land tenure system: **IR-7, UL-5.**

Tractor parks

The presence of tractor parks can have a significant impact on the scaling of laser-assisted land levelling (LLL) in Uzbekistan. Tractor parks are intended to provide farmers with access to agricultural machinery, including tractors and equipment necessary for land preparation and cultivation. Previously, mechanised services to agricultural producers were available through state-owned machine tractor parks. However, such a system of service provision was financially ineffective and most of machine tractor parks went bankrupt and the remaining was privatised[65, 66].

The new cluster system introduced in 2018 partially replaced machine tractor park's functions in providing mechanisation services to farmers. Clusters have capital enough to invest in the newest innovations and technologies to service farmers with whom they have contracts for supply of inputs. The advantage of this system is that farmers can make payments for the mechanisation services including LLL after supplying the harvest to clusters, not immediately nor in advance. There are also many reported cases of farmers who own agricultural technologies such as LLL and know how to operate them, have registered a legal entity to provide agrotechnical services. Some do so even without registering a legal entity, implying that there is a large demand for them. The fact that these facilities are there is graded with an **IR-7**. Since there is not systematic approached to such facilities and they are organized in a relatively ad hoc manner with little to no coordination among them, the use level is a lot lower: **UL-5**.

Government extension

LLL is recognized as a complex innovation, requiring focused efforts in capacity building and extension services to ensure its successful scaling. Stakeholder interviews have highlighted the issue of low capacity among farmers in adopting LLL. Despite the well-known economic benefits associated with LLL, some farmers are hesitant to adopt it due to misconceptions. An agronomist-consultant mentioned that farmers often fear that LLL may displace the fertile surface of the land and lead to lower yields. This misconception can be addressed through comprehensive training not only on LLL usage but also on general irrigation basics and techniques.

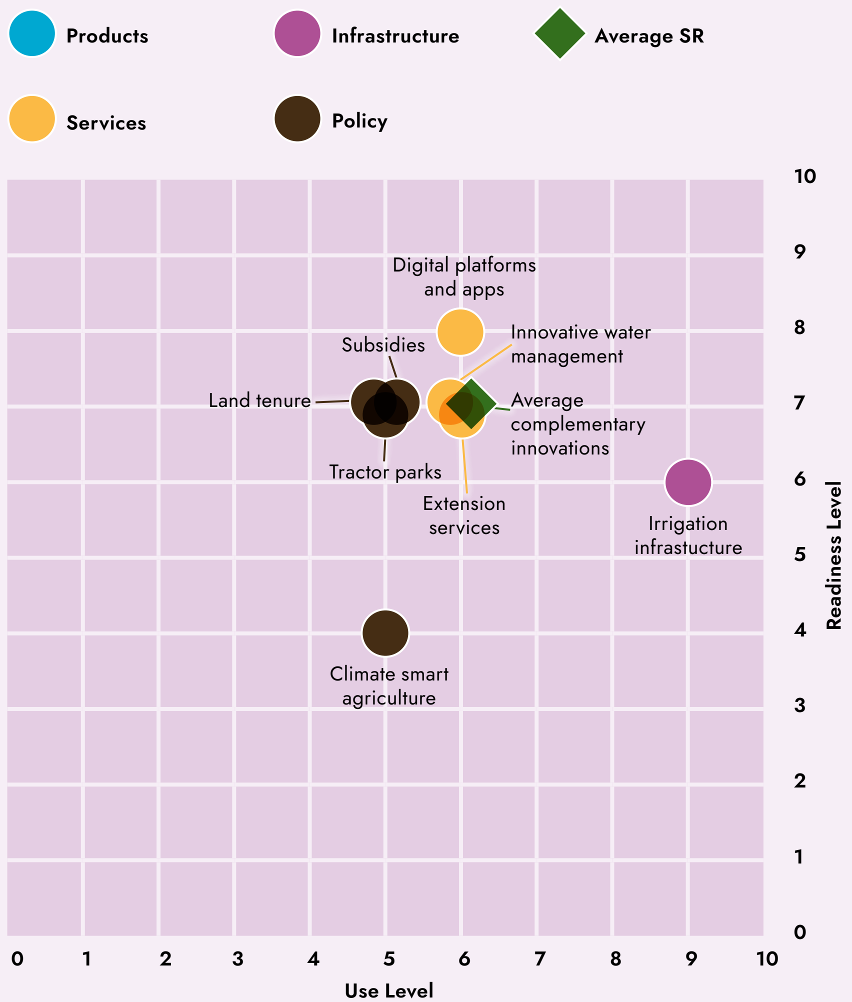
Furthermore, incidents of farmers being deceived by suppliers offering poor-quality water-saving technologies have been reported. To safeguard farmers from fraudulent suppliers and the financial burdens resulting from investing in ineffective technologies, the government established a unified electronic register known as „Tomchi-reestr." This registry includes trusted and reliable contractors and suppliers, ensuring that farmers can claim subsidies only for water-saving technologies provided by registered entities[63, 67].

To address the issue of low capacity and knowledge, the government is actively working on the development of an Agricultural knowledge and innovation system (AKIS). The goal of AKIS is to enhance the development, accessibility, and utilisation of agri-food innovation and knowledge, ultimately transforming agri-food systems and supporting agricultural producers in transitioning to market-based agriculture. While AKIS centres have been established for two years, it is still premature to assess the effectiveness of the system in delivering services, knowledge, and capacity. In June 2023, the digital AKIS was launched, but it has yet to gather a sufficient user base. Even though there are ongoing efforts to ensure the successful implementation and utilisation of AKIS to support farmers in adopting and benefiting from LLL and other agricultural innovations. At the moment the formal state sponsored extension in Uzbekistan is focussing on only two crops: wheat and cotton and for all other crops no extension is available. This led to a relatively low score for the whole extension system within Uzbekistan. The focus on these two crops means that there will be farmers who never see any extension services and are dependent on either commercial advisory services, or the advice from their neighbours and other farmers. This provides a bottleneck for the further scaling of LLL: **IR-7, UL-6**

SUMMARY OF SCALING READINESS OF THE COMPLEMENTARY INNOVATIONS

From Figure 6 can be concluded that from a scaling readiness perspective two elements of the complementary innovations are important. The first thing to notice is the low innovation readiness scores for climate-smart agriculture and the irrigation infrastructure. Especially the low innovation readiness score, combined with the high use level of the irrigation system indicates a problematic situation also known as a technological lock-in. Lock-in refers to a situation where the adoption of an innovation becomes entrenched and

Figure 6: Scaling readiness of complementary innovations for LLL



difficult to change due to various factors such as infrastructure investments or institutional arrangements. Once an innovation becomes locked-in, it becomes challenging for alternative solutions to gain traction, even if they offer potential advantages or improvements. The situation of the outdated irrigation system in Uzbekistan on the one hand makes the need for alternative irrigation systems and LLL higher, but on the other hand it also severely limits the willingness of farmers to switch, as also indicated by the low use level of the innovative water management approaches. With regard to the policy instruments that can create an enabling policy environment, the readiness level is higher than the use level. In this case this indicates the fact that on paper these instruments have been formulated and are ready, but that the practical reality, these instruments have not yet been effectively implemented, or as is the case for the state-owned tractor parks, they don't match the needs for farmers. The tenure system might look good on paper, but based on their historical experiences, farmers have little faith in (local) government policies and this negatively affects their willingness to invest in expensive technologies as LLL.

PART

C

SCALING GUIDELINES FOR LASER-ASSISTED LAND LEVELLING IN UZBEKISTAN

This section offers practical guidelines for scaling LLL based on the assessment findings. These scaling guidelines present actionable steps and strategies to overcome barriers and enhance the scaling process. Key considerations, such as policy instruments, capacity building, and stakeholder engagement, are outlined to ensure successful scaling implementation. The scaling readiness methodology aims to contribute to a holistic and broad analysis of the scaling potential of innovations. This is necessary since not all scaling processes are automatically successful, see Figure 7.

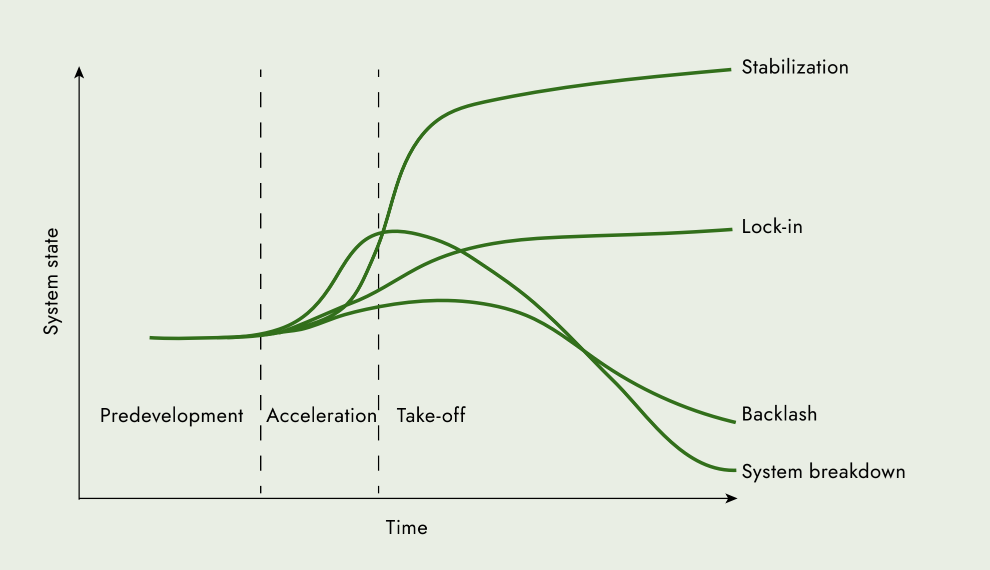


Figure 7: Overview of theoretically possible scaling processes, adapted from [68–70]

The pathways in Figure 7 highlight various outcomes and challenges that can occur during scaling. These scaling pathways shed light on the dynamics associated with the spread of innovations within societies and organisations. In the pre-development phase an innovation is in its early stages, often characterized by limited awareness and understanding among potential end-users. The innovation may face scepticism and resistance due to uncertainty and a lack of supporting evidence. According to the Scaling Readiness approach it is during the pre-development phase that the core team of innovators play a crucial role in exploring and experimenting with the innovation and further developing and testing it. The subsequent acceleration phase marks a significant increase in the adoption rate of an innovation. Through pilot projects and demonstrations, evidence and experiences are gathered, demonstrating the innovations potential benefits in a controlled environment. Positive word-of-mouth and social influence play a vital role in driving adoption. The take-off phase represents the rapid adoption of the innovation by the early and late majority of the population.. The innovation reaches a tipping point where its adoption is thought to become self-sustaining, as it becomes widely recognized as a viable economic solution. In case of a successful scaling process the innovation eventually breaks into the mainstream and a new societal equilibrium set is. This is the stabilisation phase where the innovation becomes integrated into the existing social or organisational system and becomes accepted as part of daily practices. Stabilisation signifies successful integration, widespread acceptance, and a reduction in resistance or barriers to adoption. While stabilized, innovations can continue to evolve and improve over time.

However, throughout the diffusion process, several challenges and outcomes can arise, including:

1) **Backlash** occurs when there is a negative response or resistance to the innovation. This can happen due to various reasons, such as fear of change, conflicting values, or concerns about the innovation's potential negative consequences. Backlash can slow down or hinder the diffusion process, leading to reduced adoption rates or even active opposition to the innovation.
2) **Lock-in** refers to a situation where the adoption of an innovation remains limited or fails to gain significant traction Lock-in refers to a situation where the adoption of an innovation becomes entrenched and difficult to change due to various factors such as infrastructure investments, network effects, or institutional arrangements. Once an innovation becomes locked-in, it becomes challenging for alternative solutions to gain traction, even if they offer potential advantages or improvements. Lock-in can occur when there are high switching costs, strong network effects, or when the innovation becomes deeply embedded in existing systems or practices. While lock-in can provide stability and efficiencies in the short term, it may limit the ability to adapt to changing needs or take advantage of emerging innovations in the long term.
3) **System Breakdown** occurs when the adoption of an innovation disrupts or challenges the existing social or organisational system to an extent that it leads to dysfunction or resistance. This can happen when an innovation conflicts with deeply rooted beliefs, power structures, or established practices. System breakdown can create significant resistance and obstacles to widespread adoption, necessitating adjustments or changes in the innovation or the system itself.

The aim of the scaling guidelines is to identify the different challenges that potentially might hamper the scaling of LLL in Uzbekistan and to prevent situations of breakdown, lock-in or backlash. By critically discussing the results of the Scaling Readiness assessment, it should become possible to navigate obstacles, anticipate resistance, and develop strategies to facilitate successful scaling and long-term impact. Specifically, this part of the report provides answers to the following question:

- ***What should the interventions working on the LLL need to prioritize to achieve high impact in order to reach its scaling potential?***

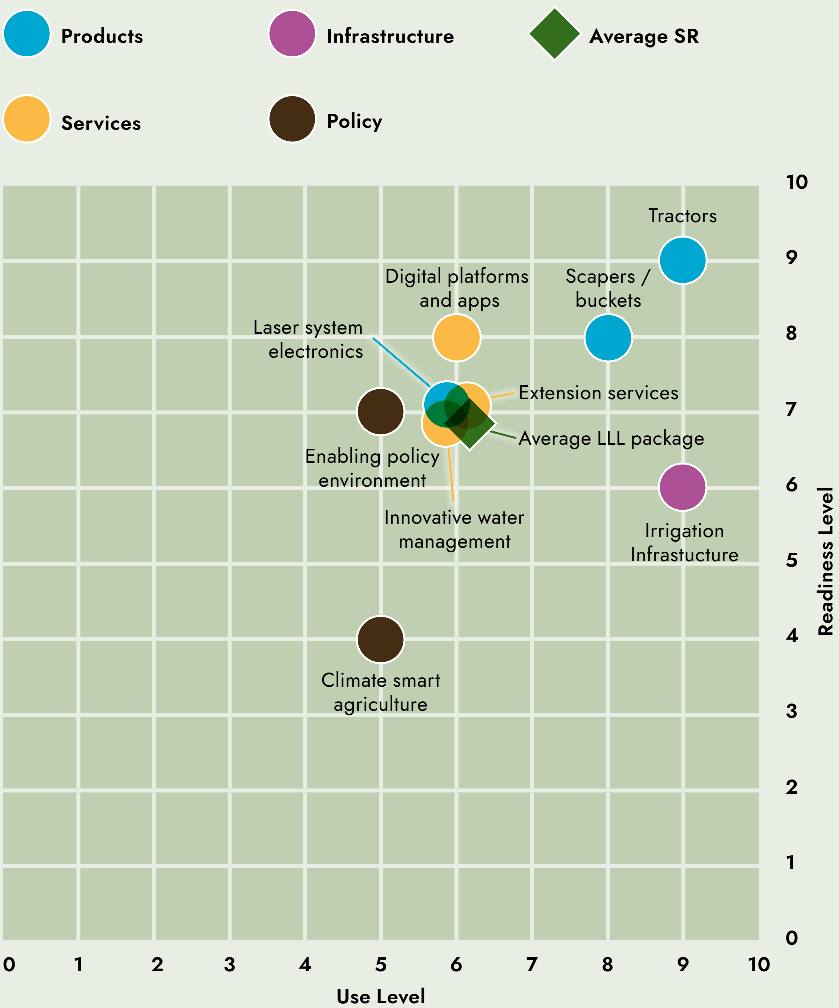
The Scaling Guidelines are at the strategic level. They aim to be a first reference for designing or adapting strategies and can be followed by a detailed action plan that can be integrated into operational plans of interventions working on LLL in Uzbekistan.

This part starts with a summary of the main findings from the innovation profile and Scaling Readiness assessment, followed by concrete recommendations for policymakers and stakeholders.
The Scaling Readiness measures and the evidence sources are presented but not articulated in this part. More information about the measures can be accessed from the Innovation Package Profile presented in Part A. Detailed explanations about the measures and the evidence sources used to do the assessment can be accessed from the Scaling Readiness assessment in Part B.

In Figure 8 the complete overview of both the core and the complementary innovation scores are depicted. The figure also makes a distinction between different types of innovations: the mechanical products that make up the core innovation package of LLL, the services associated with disseminating new practices and finally the new policy instruments that have to be designed and implemented. In part B we have discussed these scores more in depth. Here we will limit the discussion to what these scores mean for the scaling guidelines.

The technical components of the core innovation: the tractors, scrapers and electronics parts score relatively high on their scaling readiness. Overall, the core components of the laser-assisted levelling in Uzbekistan are somewhere in the acceleration phase with more and more LLL systems being sold. However, several challenges and considerations need to be addressed for effective scaling. Two of the most persistent bottlenecks for the scaling of LLL in Uzbekistan are related to its **affordability** (LLL is expensive) and its **perceived complexity:** farmers are afraid to wreck their expensive equipment, or to ruin their soils by applying the technology in a wrong way.

Figure 8: Scaling readiness scores for core and complementary innovations



MEASURES TO ENHANCE AFFORDABILITY

In order **to enhance the affordability,** there are different measures that can be implemented, both direct measures and indirect measures, that can affect the decision of farmers to laser level their land.

Financial support mechanisms: Develop and implement financial support programmes or subsidies specifically targeting small and subsistence farmers to overcome the price barrier associated with LLL equipment. This can be done through government initiatives or partnerships with financial institutions. In recent years existing subsidy programmes have shifted somewhat from subsidies targeted at farmers, towards subsidies for manufacturers who produce LLL systems locally. Subsidies are now only available for those locally produced LLL systems. Although such subsidies can help in affordability, for many small farmers the price gap will still be too big and they won't be interested in owning their own machine. The fact that laser levelling also doesn't have to be done every year reduces the attractiveness of owning your own system for small farmers even further. Subsidies targeted for complete systems are therefore only for a section of (large) farmers attractive.

Facilitate equipment-sharing models: The second option is to establish platforms or cooperatives where farmers can share or rent LLL equipment, reducing the individual cost burden and making it more accessible to a larger number of farmers. One of the main advantages of LLL compared to other more specialised irrigation systems is that it allows farmers to pool their financial resources and buy one together. Although the existing state-owned **tractor parks** are aimed at just doing that, in practice, they are considered not to be functioning well, and many of them are (on the verge of being) bankrupt. Options for moving from state-owned and managed sharing facilities towards farmer-owned models like cooperatives could be a way to revitalise them.

Indirect measures that influence investment decisions

Since LLL is seen as a relatively expensive technology, farmers want the security that they will be able to recuperate their investments. **Clear and secure land tenure rights are essential** for farmers to make long-term investments in technologies like LLL.

Policies that establish a transparent and efficient land registration system, protect land rights and ensure equitable land distribution can provide the necessary confidence and incentives for farmers to invest in land levelling equipment and practices. Strengthening land tenure security not only encourages farmers to adopt LLL but also promotes overall agricultural productivity and sustainable land management. Secondly, **water pricing policies** can also play a critical role in investment decisions by farmers. Fair and efficient water pricing mechanisms can incentivise farmers to adopt water-saving technologies like LLL. By aligning water prices with the true cost of water provision and encouraging efficient water use, farmers are motivated to invest in technologies that improve water management and reduce water wastage. Transparent and well-designed pricing policies create economic incentives for farmers to implement LLL as a means to optimise water resources, improve crop yields, and reduce production costs. However, this might necessitate investing in proper monitoring systems to give insight into the water usage of individual farmers. Finally, **good governance practices**, such as fighting corruption and ensuring access to independent judges, are crucial for creating an enabling environment for farmers' investments. A transparent and accountable governance system instils confidence in farmers, ensuring that their investments are protected, and their rights are upheld. Effective governance reduces bureaucratic barriers, streamlines administrative processes, and provides a fair and impartial legal system to resolve disputes. Access to independent judges and mechanisms to challenge government decisions are essential for farmers in case of any grievances or challenges they may face during the implementation of LLL or other agricultural investments.

REDUCE THE PERCEIVED COMPLEXITY OF LLL

The second important bottleneck we identified through our Scaling Readiness assessment is the perceived complexity of the laser land levelling that is reflected in the low use level of the laser levellers. Farmers are afraid of wrecking the sensitive electronic elements of the system or applying the system in such a way that their valuable topsoil will be ruined. In order to **reduce this perceived complexity**, some other measures are also important.

Simplifying and streamlining LLL technology

A user-friendly design could be improved by collaborating with equipment manufacturers to simplify the design and operation of LLL equipment, reducing the complexity of electronic systems. This will make the technology more user-friendly and accessible to farmers with varying technical skills.

Provide technical training and support, expand pilot and demonstration projects

To effectively scale LLL in Uzbekistan, an approach that combines various strategies and collaborations is essential. One key measure is capacity building and knowledge sharing, which involves providing comprehensive training programmes to educate farmers on the operation, maintenance, and troubleshooting of LLL equipment. Technical support networks should be established to address any issues faced by farmers during implementation, fostering a supportive environment for successful adoption. In addition, farmer-to-farmer learning can play a vital role in scaling LLL. Encouraging the formation of farmer networks or cooperatives facilitates the sharing of knowledge and experiences among experienced LLL users and their peers. This peer-to-peer learning and support system builds trust, fosters a sense of ownership, and empowers farmers to embrace LLL technology. To showcase the benefits and feasibility of LLL under diverse agroecological conditions, expanding pilot projects and demonstrations across different regions of Uzbekistan is crucial. These initiatives serve as practical examples, providing tangible evidence of the positive impacts of LLL. Through pilot projects, farmers and stakeholders gain confidence in the technology and are more likely to adopt it on a larger scale.

By embracing ICT tools, digital platforms, and phone-based apps

Uzbekistan can harness the power of technology to enhance the adoption and scaling of LLL. These tools provide opportunities for knowledge dissemination, improved farm management, and collaboration among stakeholders. With the right policy measures in place, Uzbekistan can unlock the full potential of these technologies and pave the way for a sustainable and technology-driven agricultural sector. Firstly, the government can invest in the expansion of digital infrastructure, ensuring reliable internet connectivity and mobile network coverage across rural areas. This would enable widespread access to ICT tools and phone-based apps, bridging the digital divide and reaching a larger number of farmers. Secondly, policies can be formulated to incentivise the use of ICT tools and digital platforms in agriculture, and this includes making them **less of a one-way street for government to communicate and turn them into genuine knowledge-sharing platforms** for farmer-to-farmer communication.

LLL AS A TOOL TO FACILITATE THE TRANSITION TOWARDS MORE EFFICIENT IRRIGATION

In addition to enhancing affordability and reducing the perceived complexity, some of the other complementary innovations also offer opportunities to increase the scaling process. In this regard, the new **water management approaches and the irrigation infrastructure** are closely related. The scaling readiness of the irrigation infrastructure can be evaluated as a classic form of technological lock-in with a high use level among farmers but a deteriorating innovation readiness. The existing infrastructure, which primarily consists of canal-based irrigation systems, has been in place for many years and is deeply embedded in the agricultural practices and policies of the country. This lock-in is characterised by path dependency, where the established infrastructure and associated norms and regulations create inertia, making it difficult to introduce and adopt new technologies. The repercussions of this lock-in are twofold. Firstly, the canal-based irrigation system is known for its inefficiencies, including water losses due to evaporation, seepage, and inadequate water distribution. These inefficiencies result in uneven water supply and suboptimal water management, leading to issues such as waterlogging, soil erosion, and nutrient leaching. The lack of precision in water application affects crop yields and overall agricultural productivity. Secondly, the lock-in perpetuates the reliance on traditional irrigation practices, hindering the adoption of innovative water management approaches that can address these challenges and improve water-use efficiency.

In the current situation, LLL is seen as an alternative way of innovative water management option. Because of the high costs of implementing LLL, there is a competitive relationship between LLL and other technologically advanced water management options, such as drip irrigation. However, technically, LLL can operate well with a number of novel irrigation approaches. By first applying LLL, even the traditional irrigation approaches become more efficient and work better. This offers opportunities for LLL to act as a kind of transition tool that can help with the transition from the existing canal-based irrigation system to more efficient and precise water management approaches. By applying laser levelling, a farmer could increase productivity and profitability in the short term, eventually allowing him or her to invest in other advanced forms of irrigation techniques. However, for this scaling pathway to become available, the LLL techniques need to become a lot cheaper and more easily available, and that brings us back to the earlier-mentioned issue of affordability.

CSA AS AN OPPORTUNITY FOR SCALING

Climate Smart Agriculture is one of the lowest-scoring complementary innovations both in use level and innovation readiness. The reason for this is that the debate on the practical applicability of CSA is still being held within the scientific realm, and practical applications, especially within the context of Uzbekistan, are not yet available. However, despite these low scores, we don't consider CSA as a bottleneck for scaling. LLL could potentially be made part of CSA, but the scaling of LLL doesn't critically depend on the development of CSA. Instead, we consider the scientifically contested status of CSA as an opportunity for LLL. From our analysis, it is clear that LLL fits very well with the principles of CSA that emphasise sustainable and climate-resilient agricultural practices that aim to enhance productivity, adapt to climate change, and mitigate its impacts. LLL aligns well with the principles of CSA by promoting efficient water management, reducing soil erosion, and enhancing resource-use efficiency. Furthermore, CSA is becoming increasingly popular at the international level, with a wide range of stakeholders engaging in collaborations and partnerships that include government agencies, research institutions, NGOs, and private sector organisations. By integrating LLL explicitly into the storyline of CSA, the existing networks and platforms aimed at establishing CSA can be accessed, and this, in turn, can promote the adoption of LLL by providing access to resources, technical expertise, and financial support.

COLLABORATIONS AND PARTNERSHIPS TO ENHANCE SCALING

Collaboration and partnerships among key stakeholders are also crucial in order to scale laser-assisted land levelling in Uzbekistan. Different types of stakeholders can contribute their expertise, resources, and support in different ways. Potential partners include private companies, NGOs, research institutes, and international donors, each playing a specific role in the partnership.

Private companies, such as agricultural equipment manufacturers, can contribute by developing more affordable LLL equipment or offering financing options to make it accessible to small farmers. Additionally, farm machinery rental companies can facilitate equipment-sharing models, allowing farmers to share or rent LLL equipment, reducing individual cost burdens. Technology providers can also play a role by simplifying and streamlining LLL technology, making it more user-friendly and less complex for farmers. ICT companies can be engaged to facilitate digital platforms for knowledge exchange among farmers.

NGOs, particularly agricultural development organisations, can provide crucial support through capacity-building efforts. They can offer training programmes, technical assistance, and extension services to farmers, focusing on LLL operation, maintenance, and troubleshooting. Farmer cooperatives or associations can establish networks to facilitate farmer-to-farmer learning and knowledge sharing, allowing experienced LLL users to mentor and support fellow farmers in adopting and implementing LLL practices. In addition, they can play a role in the leasing of LLL equipment.

Research institutes, such as agricultural research institutions and climate and water management research institutes, can contribute their expertise. They can conduct research on LLL's technical aspects, optimise its design and operation, and provide evidence-based recommendations for its effective implementation. They can also explore the compatibility of LLL with other innovative water management approaches and provide guidance on integrating LLL into sustainable agricultural practices. Especially for the further development of Climate-Smart Agriculture and the integration of LLL within CSA, researchers can play an important role.

International donors, including development agencies, organisations, and agricultural research centres, can play a significant role in scaling LLL in Uzbekistan. They can provide financial support and technical expertise to implement subsidy programmes, develop financial mechanisms, and establish platforms for equipment-sharing models. They can also support capacity-building initiatives and pilot projects to demonstrate the benefits and feasibility of LLL. Moreover, international agricultural research centres can share their knowledge and expertise in LLL and sustainable agriculture, providing guidance on best practices and supporting research and development efforts.

Through collaboration with these diverse stakeholders, Uzbekistan can enhance affordability, reduce perceived complexity, promote LLL as a complementary tool, and integrate LLL into Climate Smart Agriculture (CSA). By leveraging the expertise and resources of private companies, NGOs, research institutes, and international donors, the scaling of LLL can be effectively supported, contributing to the development of a more efficient and sustainable agricultural sector in Uzbekistan.

CONCLUSIONS

In conclusion, Laser-assisted land levelling holds great potential for scaling in Uzbekistan, given its ability to enhance water management, improve crop yields, and contribute to sustainable agriculture.

The successful implementation and scaling of laser-assisted land levelling technology in Uzbekistan requires a multi-faceted approach that addresses affordability and technology simplicity. LLL can be a great add-on for existing irrigation technologies and, as such, play an important role in the transition towards more modern and efficient irrigated agricultural systems. By implementing the recommended strategies, such as enhancing affordability, simplifying it, addressing institutional constraints, and fostering stakeholder collaboration, Uzbekistan can overcome the existing barriers and unlock the full potential of LLL technology. This will lead to improved agricultural productivity, water efficiency, and economic well-being for different types of farmers, ultimately contributing to the sustainable development of the agricultural sector in Uzbekistan.

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APPENDIX A: Summary of Stakeholder Interviews

INTRODUCTION

This report summarises the findings from the series of interviews conducted as a part of the Scaling Readiness assessment. The main purpose of the assessment was to identify the readiness and use levels of laser-assisted land levelling (LLL) in Uzbekistan, findings which will inform future research, development and interventions in this area.

Several representatives from stakeholder groups were invited for an interview in order to identify the benefits and challenges of using laser-assisted land levellers, as well as to get an indication of the general use level of LLL in Uzbekistan. The insights from the interviews helped to validate the literature review findings.

METHODOLOGY

Three interviews were conducted online through a Zoom video call. Interviews were conducted by Frans Hermans – Scaling Readiness assessment consultant, and Aygul Djumanazarova- Scaling Readiness assessment facilitator.

The first interview was with a soil scientist, and it took place on 5 May at 12 am Tashkent time and lasted about 1.5 hours. The second interview took place on 5 June with cotton and wheat farmers.

The third interview was with government representatives from the Ministry of Agriculture. Two civil servants from two different units relevant to the subject of LLL participated.

Additionally, there were several targeted informal interviews/communications with other stakeholders from the sector, including a short list of questions that was emailed to several farmers.

RESULTS

Interviews conducted revealed that the use level of LLL systems varies across different crops and regions. It had wider use specifically in the Khorezm region and the Karakalpakstan Autonomous Republic: regions with higher salinity levels and poor water supply. The innovation had a much higher demand among farmers producing cotton, wheat and rice. Farmers who cultivate crops that do not require significant amounts of water expressed that adopting laser-assisted land levelling systems was not economically viable.

There was a unanimous consensus among respondents regarding both the advantages and disadvantages of the innovation. The main reported benefits were increased yield by 15–30 %, water saving by 15–20 %, easier irrigation and land management. On the other hand, the primary drawbacks that hinder the widespread adoption of this innovation are its high cost and a lack of sufficient knowledge about its implementation. A noteworthy point raised was that agricultural producers primarily invest in laser-assisted land levelling systems with the primary objective of achieving economic benefits through higher yields, rather than focusing on water conservation purposes.

The availability of government support, such as subsidies and loans with subsidized interest rates, has played a crucial role in the decision-making to adopt LLL. Nonetheless, despite these incentives, farmers still perceive the technology as costly. A farmer highlighted that it would have been beneficial if the government temporarily reduced the yield targets/ forecasts for a few years, considering the potential risk of lower yields during the initial years of LLL adoption.

Finally, it is important to note that both service providers and farmers highlighted the limited capacity among farmers in adopting LLL techniques. As an illustration, the initial pioneers had to learn how to use LLL through trial and error, in the absence of extension services and adequate training. Today certain proactive farmers with necessary skills and knowledge provide leveling services neighbouring farmers' lands for a fee.

Clusters, new players in the sector, also provide LLL services to those farmers whom they contract for supply of inputs. However, the respondent noted that they do not own enough technology to cover the demand entirely.

CONCLUSION

Respondents feel that potential interventions to scale the LLL in Uzbekistan should focus on capacity building for farmers. The government's efforts to promote the technology were viewed as somewhat conflicting: providing subsidies, the procedure for which is known for excessive red-tape. The regulatory environment has seen many amendments to legal acts regulating the adoption of water saving technologies.

In order to ensure the effective use of public budget resources, it is deemed essential to supplement subsidies with appropriate training and capacity building for those who adopt the technology. This approach will also enable farmers to fully utilize LLL and get return on their investment. To convince risk averse farmers, the government could lower its production forecast/targets set for farmers for two years following the adoption to allow the farmer to experiments without fear of losing the right to land use.