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DIVERSIFICATION OF WHEAT-BASED PRODUCTION SYSTEM
Using Mung Bean in the Dry Areas of Uzbekistan

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Science for resilient livelihoods in dry areas

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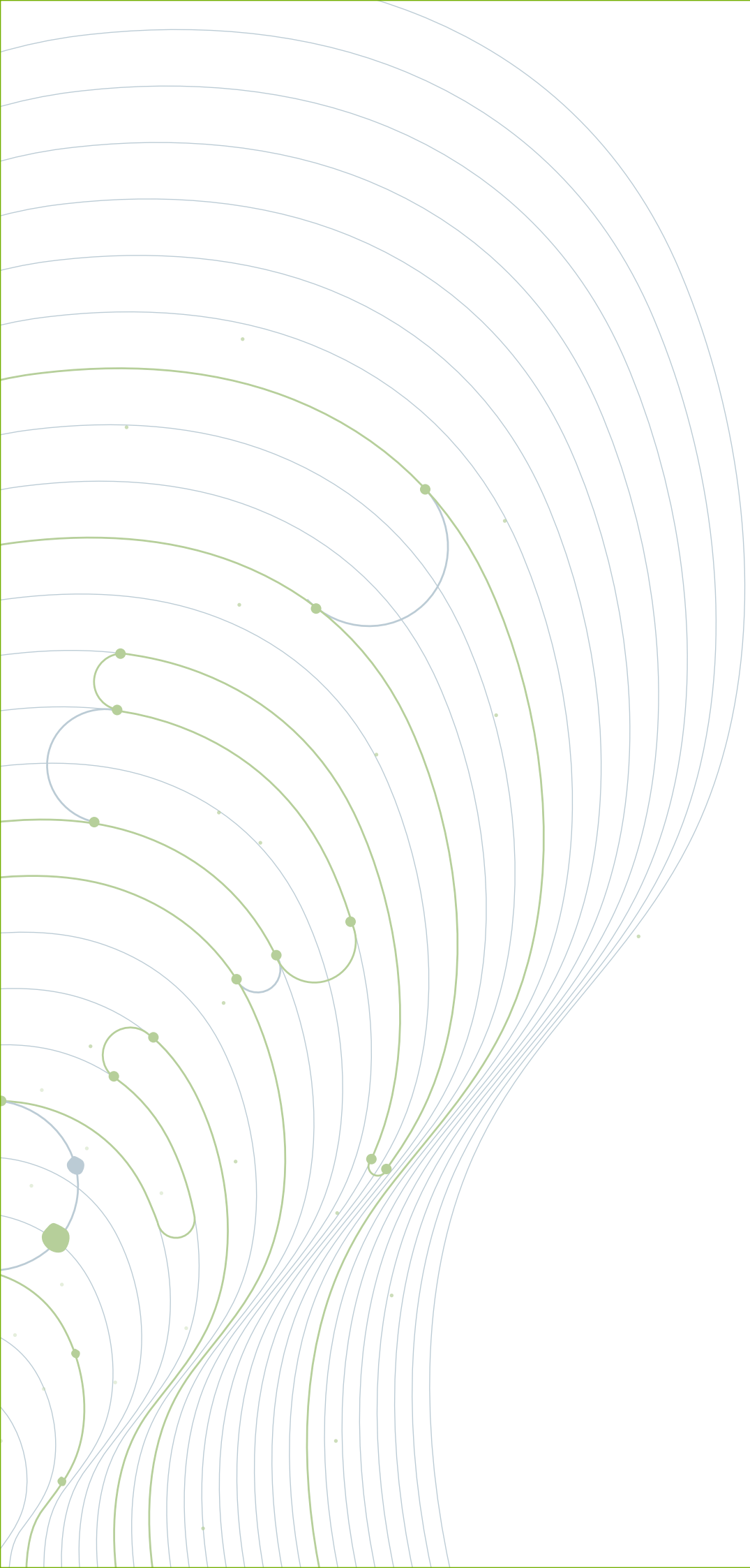

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Diversification of wheat-based production system using mung bean in the dry areas of Uzbekistan
An exploratory assessment of the Scaling Readiness of a crop rotation intervention in the drylands.

An innovation of the International Centre of Agricultural Research in Dry Areas (ICARDA).

This assessment is carried by the Monitoring, Evaluation and Learning team (MEL) of ICARDA.

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Photos: Wikimedia Commons
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Innovation at a glance

DIVERSIFICATION OF WHEAT-BASED PRODUCTION SYSTEM USING MUNGBEAN IN THE DRYLANDS

Context

- Arid climate
- <200mm annual precipitation
- Wheat-based cropping systems

West Uzbekistan

The Targets

Working principle

1. Wheat is harvested in early summer, and land is tilled and harrowed in preparation for mungbean sowing.

2. Mungbean is mechanically seeded in early September then manually harvested end of October.

Advantages and Disadvantages

- increases production and farm net-income
- improves soil health
- reaps higher market price

- increases workload due to extra crop
- sensitive to dry spells and may require supplemental irrigation

BACKGROUND

Source: WOCAT

Short duration mung bean varieties for economic, edaphic and environmental benefits in Central Asia. Central Asia suffers from degraded land and a harsh climate characterized by extreme temperature differences and low precipitation. Uzbekistan is no exception to this. Its temperatures in summer could rise up to 50 degrees Celsius, and annual precipitation is limited to less than 200 millimeters in the western part. Due to harsh winter, crop production is limited primarily between April and September, thereby limiting one crop a year. This makes it hard for farmers to ensure agricultural production and food security.

Winter wheat is commonly grown to achieve food security and enhance farm income as it is suited to the environment. However, the continuous cultivation of winter wheat and cotton has led to severe soil degradation and nutrient depletion. Inevitably, this makes the soil unsuitable for crop cultivation in the long run. In response to this challenge, the International Centre of Agricultural Research in Dry Areas (ICARDA) introduced short-duration improved mung bean varieties in 2014 in the wheat-based cropping system. The short-duration mung bean variety has been introduced in Uzbekistan from the World Vegetable Center. mung bean (or "green gram": *Vigna radiata*) is a leguminous crop, which replenishes soil organic matter and fertility through nitrogen fixation. By including mung bean in the wheat production system, soil health is improved, the fallow period is reduced, and farmer incomes are increased. The increased farm income is due to the reduced amount of fertilizer required, increased yields and higher selling prices than wheat. Further, environmental benefits are reaped from the lower application of energy-intensive mineral fertilizers and the higher carbon sequestration. mung bean could bring a profit of up to 2000 USD per hectare in 100 days or less, while winter wheat profits are not more than 600 USD per hectare in an 8- to 9-month period. These numbers show the great benefit of incorporating mung bean. Scientists have demonstrated that cultivating only mung bean would lead to even higher profit margins by growing longer-duration varieties but concluded that adoption is unrealistic as wheat is predominantly grown for food security.

One downside to the incorporation of mung bean in wheat-based systems is the increased irrigation demand since mung bean requires additional water. However, in economic terms, its water productivity is much higher than wheat and cotton.

Figure 1. Scientists and farmers investigating mung bean plants (left). Rows of mung bean crops cultivated in the field (right).

The wheat-mung bean system follows the following crop rotation. After the wheat harvest in June–July, the field for mung bean is tilled and harrowed before seeding. mung bean is mechanically seeded and manually harvested in September–October respectively. In this growing period, the field is weeded either manually or by a cultivator, irrigated, fertilizer mechanically applied or hand broadcast and mechanically weeded. However, weeds are not a serious threat to mung bean' due to the hot summers and mung bean's broad canopy coverage of the ground. In conclusion, short-duration improved mung bean varieties can benefit local farmers' incomes and add resilience while reducing land degradation within a commonly used intensive production system.

Technical Specification

Figure 2 (left) represents the spacing of winter wheat. The following dimensions relate to Winter Wheat cultivation: A = Plant spacing within row = 2 to 4 centimeters; B = Spacing between rows = 15 centimeters. The plant density is 4.5 million to 5 million plants per hectare.

Figure 2 (right) represents the spacing of mung bean. The following dimensions relate to mung bean cultivation: A = Plant spacing within row = 8 to 10 centimeters; B = Spacing between rows = 45 to 60 centimeters. The plant density is 200,000 to 250,000 plants per hectare.

Figure 2. Technical specification of winter wheat and mung bean cultivation.

SCALING READINESS AND CONCEPTS

Scaling Readiness (SR) is a conceptual approach used to improve the scalability of an innovation package within a specific context by guiding users in identifying the barriers to scaling i.e. bottlenecks. It is a dynamic process where innovation packages, bottlenecks and SR scores change over time and place as a result of changing contexts or innovations. This exploratory SR assessment includes two steps. The first is to **characterize** the innovation, and the second is to **diagnose** the components of the innovation.

This section starts by briefly describing the concepts and logic used in SR, followed by the characterization and diagnosis of the innovation, i.e., application of SR concepts.

Characterization

Characterizing an innovation consists of defining the innovation, the target for its scaling, the novel components (aka., complementary innovations), and the innovation package. This relates to the following concepts:

- **The Core Innovation:** the innovation to be scaled. This is context-independent, hence more general, and broadly formulated.
- **The Target:** where to scale, for whom, and for what (SDGs)
- **The Complementary Innovations:** co- (or sub-) innovations that are indispensable for the successful scaling of the core innovation. These are context-specific and can be viewed as the enabling environment.
- **The Innovation Package:** a comprehensive statement of the interaction between core and complementary innovations, featuring the context (country + subnational level), the target beneficiaries, and targeted SDGs.

Complementary innovations can be of different types. They are distinguished as:

Feature: a modification of something, e.g. cash crops to a cropping system, lightweight tractors, etc.

Tool: a thing used to support a process, e.g. machinery, phone app, etc.

Product: an input such as material or supplies, e.g., seeds, fuel, seedlings, etc.

Principle: a change in belief, behavior, or assumptions (something intangible), e.g., gender equality or farmer perception.

(Institutional) Arrangement: an arrangement between entities, e.g., strategy, cooperatives, contracts, meetings etc.

Service: a service provided to stakeholders, e.g., capacity development, loan systems/ micro-financing, extension, agricultural mechanization hiring, etc.

Technique: how to do something, e.g., rainwater harvesting or raised seedbeds.

Complementary innovations can be brainstormed and synthesized in relation to the following enabling conditions:

1. **Access** (infrastructure; digital info/comms/data; mechanization; agri-inputs; markets; finance; etc.)
2. **Socio-culture** (public-private extension; training/capacity; innovation user trust; behavioural change and paradigm shifts; user/consumer preferences; etc.)
3. **Policies** (legal frameworks; business models; political commitment and investments; stakeholder collaborations; incentive mechanisms)
4. **Economic** (funding; functional value chains; etc.)
5. **Awareness**: to make relevant people aware of the innovation (a radio broadcast; field days; farmer field schools; etc.)
6. **User-friendliness**: to simplify the science complexity so it is understood (a simple grazing calendar rather than formulas for grazing capacity; etc.)

Diagnosing

The complementary innovations are diagnosed so that the bottleneck hindering scalability is revealed. Diagnosing consists of calculating the Scaling Readiness Score – the product of multiplying the Innovation Readiness Score and the Innovation Use Score. These two concepts are defined and scored as follows (source: MELCOP/PRMF Glossary).

Innovation Use is a metric used to assess the extent to which an innovation is already being used, by which type of users, and under which conditions, with a scale ranging from no use (lowest level — 0) to common use (9).

Innovation Use Levels	Generic level label	Generic level description
9	End-users/ beneficiaries (common)	The innovation is commonly used by end-users or beneficiaries who were not involved in the initial innovation development
8	End-users/ beneficiaries (rare)	The innovation is used by some end-users or beneficiaries who were not involved in the initial innovation development
7	Unconnected next-user (common)	The innovation is commonly used by organizations not connected to partners involved in the initial innovation development
6	Unconnected next-user (rare)	The innovation is used by organizations not connected to partners involved in the initial innovation development
5	Connected next-user (common)	The innovation is commonly used by organizations connected to partners involved in the initial innovation development
4	Connected next-user (rare)	The innovation is used by some organizations connected to partners involved in the initial innovation development
3	Partners (common)	The innovation is commonly used by partners involved in the initial innovation development
2	Partners (rare)	The innovation is used by some partners involved in the initial innovation development
1	Project lead	The innovation is used by the organization(s) leading the innovation development
0	No use	The innovation is not used

Innovation Readiness is a metric used to assess the maturity of an innovation (its preparedness for scaling) with a scale ranging from the idea (lowest level — 0) to validated under uncontrolled conditions (highest level — 9).

Innovation Use Levels	Generic level label	Generic level description
9	Proven innovation	The innovation is validated for its ability to achieve a specific impact under uncontrolled conditions
8	Uncontrolled testing	The innovation is being tested for its ability to achieve a specific impact under uncontrolled conditions
7	Prototype	The innovation is validated for its ability to achieve a specific impact under semi-controlled conditions
6	Semi-controlled testing	The innovation is being tested for its ability to achieve a specific impact under semi-controlled conditions
5	Model/ early prototype	The innovation is validated for its ability to achieve a specific impact under fully-controlled conditions
4	Controlled testing	The innovation is being tested for its ability to achieve a specific impact under fully-controlled conditions
3	Proof of concept	The innovation's key concepts have been validated for their ability to achieve a specific impact
2	Formulation	The innovation's key concepts are being formulated or designed
1	Basic research	The innovation's basic principles are being researched for their ability to achieve a specific impact
0	Idea	The innovation is at idea stage

The complementary innovation (sub-innovation) that is scored with the lowest Scaling Readiness Score is considered the bottleneck, i.e., the one that prevents the core innovation from scaling. This logic is based on Liebig's law of the Minimum. This is illustrated in Figure 2 (Sartas, et al., 2020).

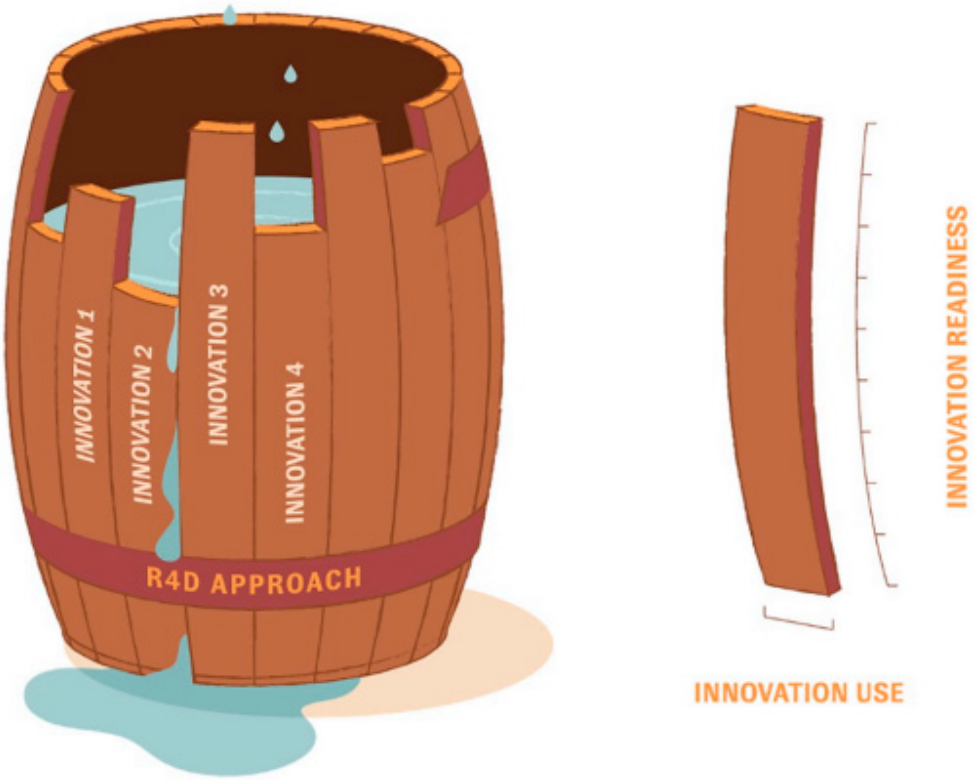

Figure 3. Liebig's barrel analogy of the law of the minimum depicted here in the context of scaling readiness.

Only experts who understand the innovations and the scaling context are qualified enough to score the core and complementary innovations for their innovation readiness and use (i.e., to serve as an informant). While rating an innovation, it is important to include references with the highest quality (e.g., scientific papers), else other reputable references (e.g., blogs). This is essential to support their scoring and base the Scaling Readiness.

SCALING READINESS ASSESSMENT OF THE INNOVATION

Characterizing

Scaling target:

To increase economic return of farmers, improve soil health and healthy diets for farmers of wheat-based irrigation systems in Uzbekistan.

Core innovation:

Short duration improved variety of mung bean – a product to allow the cultivation of mung bean in a short window in current wheat-based system; more profitable than other innovations for the short period of hot summer

Complementary innovations:

1. Early maturing wheat varieties – a product that allows early planting of mung bean, which is crucial for successful mung bean cultivation.
2. Combine harvester – a tool that saves time and labour for manual harvest.
3. Storage facility – a tool that protects grain and seed from pests and diseases, since seeds need to be protected over 9 months to maintain vigor for planting in the next year.
4. Market channels – a service that connects farmers of remote areas to the market where farmers can sell their mung bean harvest.
5. Mung bean seed – product to sow mung bean and eventually harvest.
6. Rural advisory – a service to advise farmers on how to cultivate mung bean and how to acquire the seeds.
7. Research – a service to research and develop improved varieties of mung bean and wheat.

8. Partnerships – an arrangement set up with government and non-government organizations, farmer groups and developmental partners for out-scaling the innovation for wider impact.

The innovation package:

To improve economic return, soil health, and human nutrition from the land for farmers in wheat-based systems by introducing shot-duration improved varieties of the leguminous crop mung bean and early maturing wheat varieties, in Uzbekistan.

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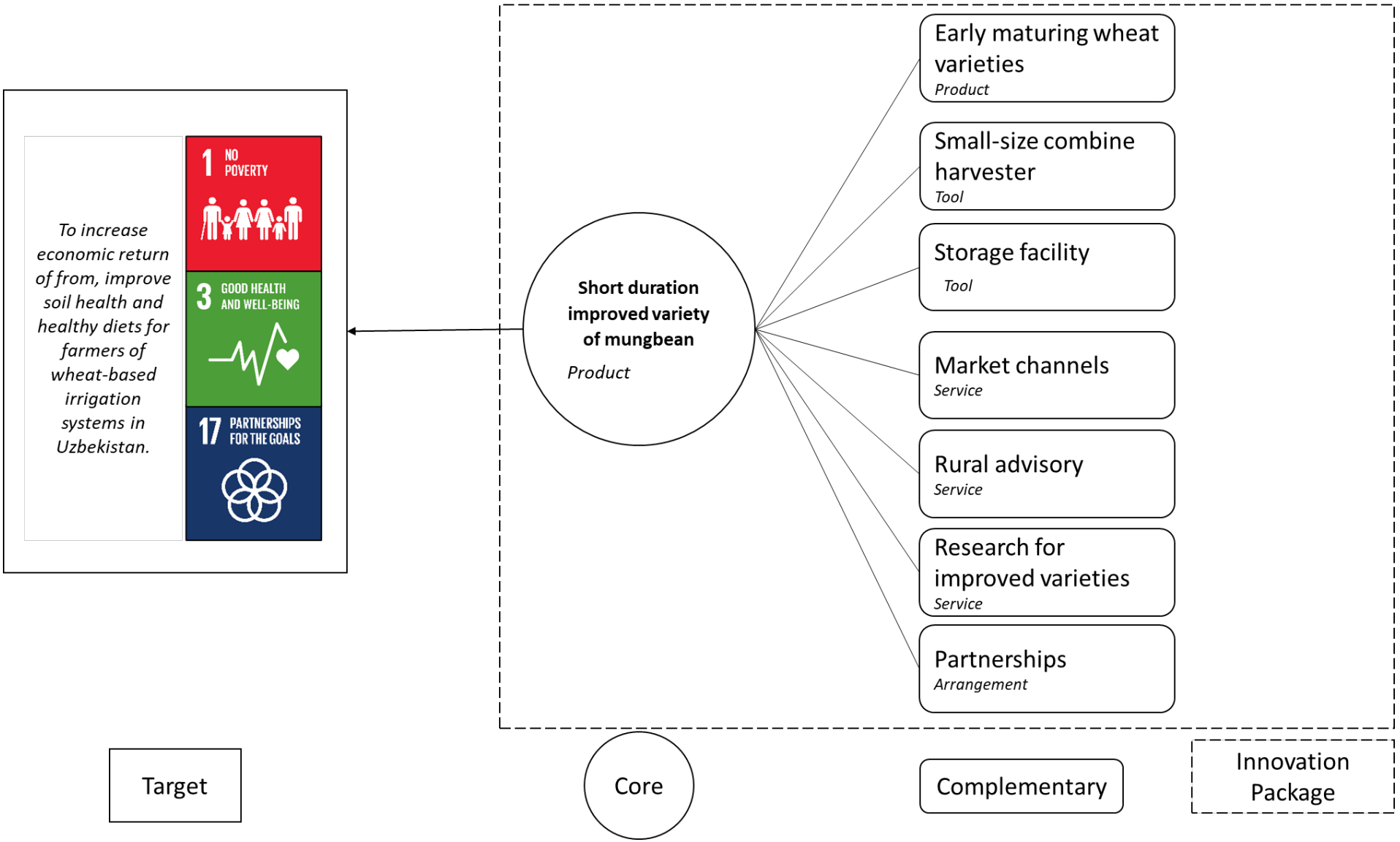

Diagnosing

The following tables show the complementary innovations, the rationale for their use and readiness, their scoring within the context of the innovation package.

Innovation Use

	Complementary innovation	Type	Rationale	Evidence	Use Score
a	Early maturing wheat varieties	Product	Wheats are typically grown, but early maturing varieties are few in cultivation.	(ICARDA, 2014); (Nurbekov, et al, 2006)	2
b	Combine harvester	Tool	Commonly and already used by farmers.	(Rani, et al, 2018)	8
c	Storage facility	Tool	Common and already in place by farmers.	(Rani, et al, 2018)	8
d	Market channels	Service	Although markets for mung bean exist, they are not used at scale.	(Kuzieva, 2015); (Rani, et al, 2018)	3
e	Mung bean seeds	Product	Mung bean seeds are used commonly, but their availability remains low due to small-scale seed production.	(ICARDA, 2014); (Ibragimov, et al., 2019); (Sharma & Mavlyanova, 2015); (Mavlyanova, 2015)	4
f	Rural advisory	Service	Not many advisors include mung bean.	(Rani, et al, 2018)	5
g	Research for improved varieties	Service	Only embraced by specific partners.	(ICARDA, 2014); (Sharma & Mavlyanova, 2015)	5
h	Partnerships	Institutional Arrangement	Partnerships are very limited.	(Sharma & Mavlyanova, 2015); (Nurbekoz, et al, 2006)	2

Innovation Readiness

	Complementary innovation	Type	Rationale	Evidence	Readiness Score
a	Early maturing wheat varieties	Product	Early maturing wheat varieties are (very) limited and more research is needed.	(ICARDA, 2014); (Nurbekoz, et al, 2006)	4
b	Combine harvester	Tool	Commonly used.	(Rani, et al, 2018)	8
c	Storage facility	Tool	Commonly used.	(Rani, et al, 2018)	8
d	Market channels	Service	For mung bean it could be more improved.	(Kuzieva, 2015); (Rani, et al, 2018)	5
e	Mung bean seeds	product	Is tested and validated on many different farms.	(ICARDA, 2014); (Ibragimov, et al., 2019); (Sharma & Mavlyanova, 2015); (Mavlyanova, 2015)	8
f	Rural advisory	Service	In theory it should help, but not widely tested here.	(Rani, et al, 2018)	5
g	Research for improved varieties	Service	Research already helped with the mung bean seeds but not well strategized.	(ICARDA, 2014); (Sharma & Mavlyanova, 2015)	6
h	Partnerships	Institutional Arrangement	Partnerships should help, but cooperation among different stakeholders in different sectors is (very) limited.	(Sharma & Mavlyanova, 2015); (Nurbekoz, et al, 2006)	3

Scaling Readiness Scores

When the Innovation Use score and Innovation Readiness score are multiplied, the Scaling Readiness Score is calculated for each complementary innovation. The results are summarized in Figure 4, and Figure 5.

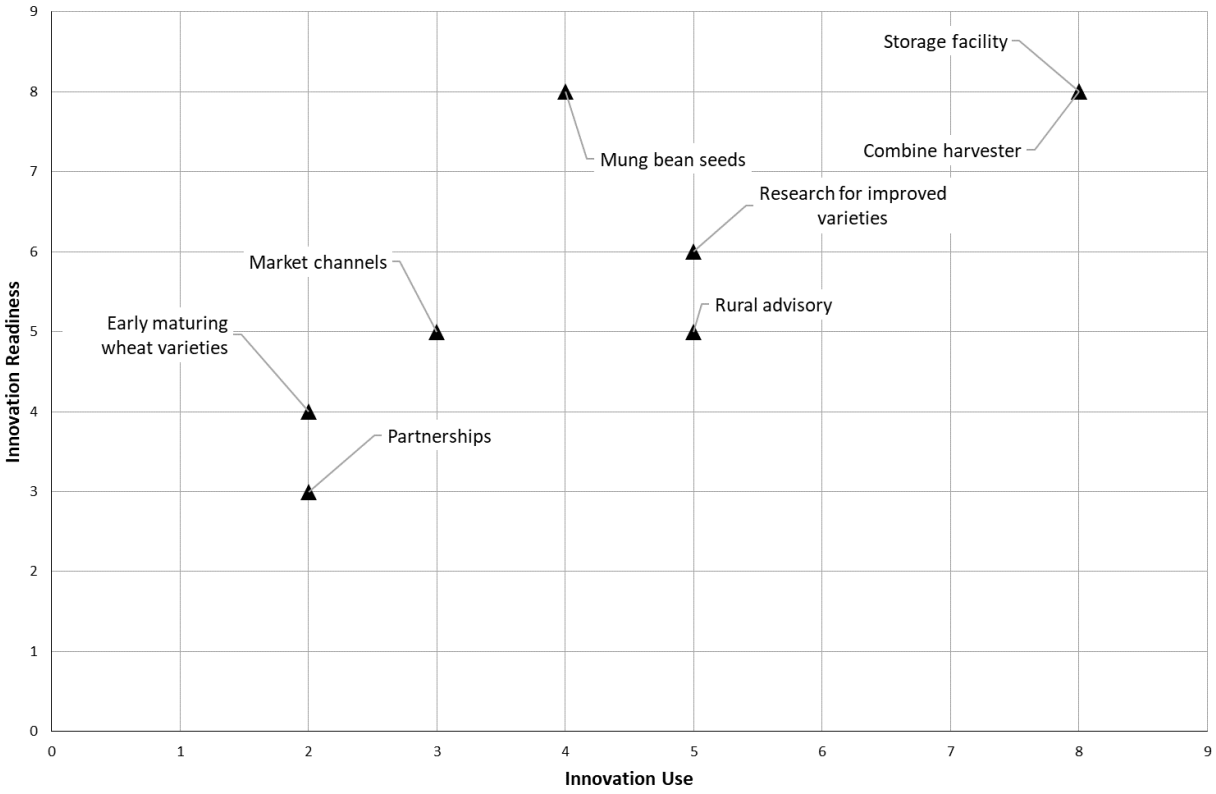

Figure 4. Scatterplot of Innovation Use and Innovation Readiness for each complementary innovation.

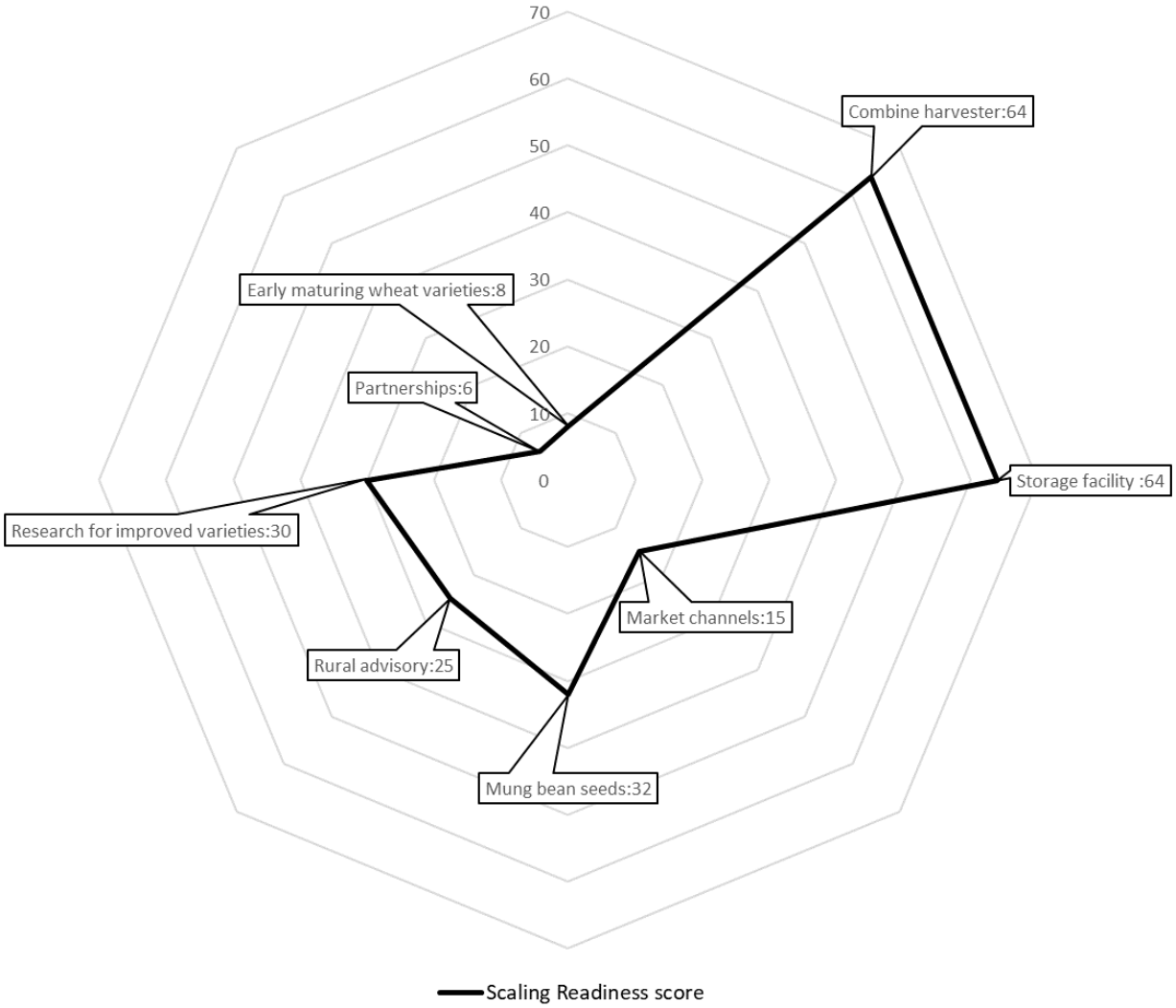

Figure 5. Radar graph plotting the Scaling Readiness score.

DISCUSSION AND RECOMMENDATIONS

This document presents an exploratory Scaling Readiness assessment of an innovation introducing a high-protein legume crop into a wheat-based cropping system in Uzbekistan. The assessment results show:

- Mung bean, an innovative crop, has shown promise but faces scaling challenges due to certain components in the innovation package. Notably, partnerships (6), early maturing wheat varieties (8), and mung bean market channels (15) have low Scaling Readiness scores, indicating the need for improvement.
- Previous research efforts focused primarily on mung bean varieties, which yielded successful results, as evident from high Scaling Readiness scores for mung bean seeds and associated research facilities. However, the current focus should shift towards developing early maturing wheat varieties to effectively incorporate mung bean into conventional cropping cycles. Establishing coordination through strong partnerships among researchers can facilitate this transition.
- The availability of improved wheat varieties can enhance the quality of rural advisory services concerning mung bean by considering the complete cropping cycle. A robust partnership, including extension services, can support the dissemination of comprehensive guidance to farmers.
- While there are existing local markets for mung bean, they remain relatively small-scale. Expanding these markets is vital to achieving the innovation package's goals and promoting scaling. A strategic approach is needed to raise consumer awareness regarding mung bean's positive effects, such as its nutritional value and soil health improvement.
- Looking closer to mung bean seeds, the innovation has proven itself with a readiness level of 8, but its use level stands at 4, primarily due to limited seed availability resulting from low-scale seed production. Strengthening partnerships with seed distributors and producers can alleviate seed shortages and increase the utilization of mung bean seeds, facilitating their widespread adoption.

REFERENCES

Ibragimov, N., Djumaniyazaova, Y., Khaitbaeva, J., Babadjanova, S., Ruzimov, J., Akramkhanov, A., & Lamers, J. (2019). Simulating Crop Productivity in a Triple Rotation in the Semi arid Area of the Aral Sea Basin. International Journal of Plant Production.Retrieved from https://hdl.handle.net/20.500.11766/10579

ICARDA. (2014). Seed production of wheat, barley, chickpea and mungbean in Action Sites in Uzbekistan and Tajikistan. CRP DS 4. 5 Activity Report. Retrieved from https://hdl.handle.net/20.500.11766/11195

Kuzieva, D. (2015). Mungbean rejuvenates a soil and consumer requested product. Farmer, 43-45.

Mavlyanova, R. (2015). Improved vegetable varieties for Central Asia and the Caucasus developed from AVRDC-The World Vegetable Center Germplasm. kin Journal of Crop Breeding and Genetics, 100-104. Retrieved from https://dergipark.org.tr/en/pub/ekinjournal/issue/22786/243177

Nurbekoz, A., Paroda, R., Bishaw, Z., Larine, M., & Amanov, A. (2006). Focus on Seed Programs: The Uzbekistan Seed Industry. Lebanon: International Center for Agricultural Research in the Dry Areas (ICARDA), https://hdl.handle.net/20.500.11766/13140

Rani, S., Schreinemachers, P., & Kuziyev, B. (2018). Mungbean as a catch crop for dryland systems in Pakistan and Uzbekistan: A situational analysis. Cogent Food & Agriculture. Retrieved from https://doi.org/10.1080/23311932.2018.1499241

Sharma, R., & Mavlyanova, R. (2015). Establishing mungbean seed production system in Kuva, Fergana. Retrieved from https://hdl.handle.net/20.500.11766/3307

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