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OPINION

Sowing the wheat seeds of Afghanistan's future

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Societal Impact Statement

The production and availability of food underpins societal stability. In Afghanistan, wheat is the major arable agricultural crop and source of dietary energy. The withdrawal of NATO allies and partner countries from Afghanistan presents numerous well-documented societal and political challenges and has impacts on immediate and longer-term food security. Conflict-impacted irrigation infrastructure coupled with growing climate instability have also contributed markedly to reductions in current food, and specifically wheat, production. Here, we review the status of Afghan wheat improvement and propose a research agenda to support the regeneration of Afghanistan's wheat and agricultural sector.

Summary

Afghanistan is a country with diverse natural ecologies in a largely arid and mountainous region. The rural sector is still considered to drive economic potential. Current social, political and economic instability along with climatic challenges are driving food and water insecurity in the wider region. In the short term, it is likely that this and the associated challenges of displacement and unemployment can only be addressed by humanitarian intervention and agrifood and nutrition support. In the medium to long term, drought, and heat, probably linked to climate change, will pose recurrent challenges for agriculture and food security that will require a much broader set of interventions to secure the rural population's livelihoods. The genetic gap, among other major challenges, must be addressed if Afghanistan is to develop its agricultural potential leading to income and livelihood improvements for farmers and stable and accessible supplies for consumers. Only thereby will the country be enabled to reap the important and long-sought trade and food security benefits derived from self-sufficiency. Here, we highlight the agricultural challenges facing Afghanistan and propose forward strategies for ensuring the future stability of wheat production, the cornerstone of Afghan agriculture.

KEYWORDS

food security, humanitarian intervention, irrigation, nutrition, plant breeding, seed systems

1 | INTRODUCTION

Agriculture is the backbone of the Afghan economy (Bolton, 2019). Historically, rural production in Afghanistan has been a mixed economy of arable enterprise, particularly wheat and livestock, fruits and vegetables. The rural sector is still considered to drive economic potential and the national policy framework for development was set out in the *Afghanistan National Peace and Development Framework (ANPDF): 2017 to 2021* (Islamic Republic of Afghanistan, 2016), a 5-year strategic plan for achieving self-reliance through sustainable development. Despite current uncertainty, the fundamental challenges that face agriculture, food security and nutrition remain largely unchanged. Especially since 2020, the triple nexus of conditions of Covid-19, conflict and climate change has caused further deterioration in the situation of the rural populations. Due to the level of violent conflict and drought as well as restrictions linked to Covid, rural populations have been pushed further towards poverty and destitution (Nemat et al., 2022). Focused on agricultural productivity and incomes, import substitution, domestic agro-industrial development and exports, National Priority Program 3 and the Comprehensive Agricultural Development Program (CADP) included rehabilitation of existing irrigation schemes and development of new networks and reservoirs and a national wheat sector plan to increase production from 4.5 to 5.9 million metric tonnes per annum (Islamic Republic of Afghanistan, 2016). This productivity increase was proposed to be achieved through biological yield increases, increasing land under cultivation, reducing post-harvest losses, developing a standardised wheat seed market and re-establishing a national grain reserve.

Wheat, both irrigated and rainfed, is the principal agricultural food crop in Afghanistan (Poole et al., 2018). The area of irrigated wheat (1,611,500 ha) is greater than rainfed wheat (1,056,700 ha), and the productivity of irrigated wheat is more than double that of the rainfed sector (2.50 compared with 1.09 t/ha), and production, import levels and yields have fluctuated over time (Foreign Agricultural Service, 2021). Bread is the major component of the Afghan diet, with per capita wheat consumption among the highest in the world. From 1976 to 1992, wheat production fell by one half: primarily as a result of extended droughts and destruction of irrigation infrastructure (Persaud, 2012). Since then, highly variable production levels have been reported, and import dependence on vulnerable neighbours such as Kazakhstan and Pakistan appears to be a permanent feature of the agricultural economy (Sharma & Nang, 2018). The 2013 National Wheat Policy (MAIL, 2013) aspired to self-sufficiency in wheat production as a major objective of Afghan agricultural policy, noting the existing gap between demand and domestic production. This has been largely attributed to the low productivity of available varieties, inadequate quality seed production and distribution with unstable climatic conditions, evolving pests and diseases and global market volatility contributing to vulnerability of production (MAIL, 2013). At the time of writing, it is evident that the escalating conflict in Ukraine will impact regional agricultural production and exports. This will result in higher prices for wheat and other staple cereals and consequent global food market turmoil. Of course, it is poor import-dependent countries and humanitarian programmes that will be most affected (Bentley, 2022).

The yield gap between Afghanistan and neighbouring ecologies is considerable: The national average productivity of irrigated wheat yield is about 2.5 tonnes/ha compared with 3.5 tonnes/ha in India (Ramadas et al., 2019). The absence of optimum technologies (e.g. on-farm mechanisation for planting, crop management and harvest) and debilitated crop management strategies (e.g. pest and disease control and availability of chemical fertilisers) are likely to play a major part in limiting productivity in Afghanistan. A consequence of low productivity is a substantial deficit in domestic production, with a significant gap for wheat between requirement and production (6.496 compared with 5.185 million tonnes; NSIA, 2021).

Afghan wheat varieties are predominantly derived from germplasm development by the International Maize and Wheat Improvement Centre (CIMMYT). Ancestry analysis showed 75% of samples assessed with DNA fingerprinting in 2015–2016 from four Afghan provinces (Kabul, Herat, Balkh and Nangarhar) were CIMMYT direct or derived releases (Dreisigacker et al., 2019) with activities focused primarily on supporting the national agricultural research system through the provision of elite, widely adapted germplasm with strong disease resistance. Recent estimates of genetic gains over 14 years (2002–2003 to 2015–2016) of testing of CIMMYT's Elite Spring Wheat Yield Trial material across 11 locations in Afghanistan documents significant grain yield progress of 115 kg/year (Sharma et al., 2021). Average yields across 11 testing locations ranged from 3.58 to 5.97 t/ha (Sharma et al., 2021). This indicates that yield potential can be increased through introduction and testing of internationally improved germplasm. Local public- and private-sector wheat breeding activities have been largely absent in Afghanistan for over a decade, driving the reliance on international breeding material. However, many issues remain with the speed of registration of new varieties and subsequent seed multiplication and distribution, the availability and suitability of accompanying technologies such as irrigation and fertilisation and linkages to market demand and the multiple sectors interacting to secure food supply.

Recent studies have characterised and described the status of wheat genetic resources in Afghanistan, notably landraces preserved by farmers and local communities (Morgounov et al., 2021; Tehseen et al., 2021). This has identified significant positive variation (compared with modern varieties) for production traits including grain yield and thousand kernel weight (Morgounov et al., 2021), indicating useful local diversity for future use in pre-breeding and breeding. Further analysis of the genetic structure of a panel of Afghan landraces has shown genetic differences based on agroecological zones, suggesting it is possible to target climate adaptation breeding targets through the use of landrace diversity (Tehseen et al., 2021). In 2002, the national gene bank of Afghanistan was vandalised, and the existing collection of crop genetic resources lost (CGIAR, 2008). This led to mobilisation of the international community to conduct emergency multiplication of duplicates held in other collections for return to Afghanistan as well as for ensuring long-term secure duplicate storage in multiple locations.

In Afghanistan, the change in government since 15 August 2021 has presented new challenges for re-energising the agricultural economy and attaining food security. Nearly 20 million people in Afghanistan—almost half the population—are facing acute hunger. Immediate humanitarian assistance is needed, followed by development support to 'to rebuild shattered agricultural livelihoods and reconnect farmers and rural communities to struggling rural and urban markets across the country' (United Nations, 2022).

In this opinion paper, we highlight current challenges facing Afghan wheat production and signal opportunities for future improvement. Although in the short term, humanitarian interventions are likely to be the major determinant and/or source of food security, we propose that strategic rebuilding of the wheat system will lay the foundation for restoring Afghanistan's agricultural production structures.

2 | AFGHAN WHEAT PRODUCTION AND DISTRIBUTION IN A CHANGING CLIMATE

In Afghanistan, more than many countries, the need for climate-resilient varieties that meet farmers' varied requirements and consumer preferences are paramount. Delivering these varieties will be primarily a function of breeding to improve traits such as heat and drought resilience, including the use of functional variation from existing landrace collections. In addition, agronomic interventions such as conservation agriculture are likely to also offer substantial benefits in buffering environmental stresses. Wheat sector development in Afghanistan has, to date, focused on enhancing seed security. Seed security is understood to be ready access by rural households, particularly farmers and farming communities, to adequate quantities of quality seed and planting materials of crop varieties, adapted to their agroecological conditions and socio-economic needs, at planting time, under normal and abnormal weather conditions. Access to relevant plant genetic resources (PGR) and expeditious release of the commercially viable materials are of prime importance. Recent studies have documented the contribution of CIMMYT germplasm to farmer uptake of improved varieties (Dreisigacker et al., 2019) and delivery of increasing yield potential over time (Sharma et al., 2021).

Further to supply of improved germplasm, the need to boost agricultural productivity through cultivation of improved varieties of all crops is a major challenge for agricultural research. Seed systems encompass the technological pathways for seed (re)distribution, a critical part of the innovation pathway from plant breeding to putative increases in agricultural production and productivity. Often there are underlying problems within the seed systems among which a common factor is deficient knowledge communication systems. The information must flow not only from researchers and distributors to farmers but also from farmers to researchers, not least through increased representation in the decision-making of public research institutes. Such representation must take into account the diversity of Afghanistan's regions in terms of soils, rainfall and irrigation sources, altitude, temperature regimes, logistics and human resources and cultures. Moreover, contextual diversity strongly influences the operation of markets and distribution systems, the choice of media and the content of effective knowledge communication and seed distribution systems.

It has long been known also that local 'informal' systems for much seed acquisition are important to smallholder farmers in low- and middle-income countries (Almekinders et al., 1994; Almekinders & Louwaars, 2002). This is true, particularly in less favoured and more heterogeneous production regions, such as those in Afghanistan. Mausch et al. (2021) emphasised that attention to farmers' needs and preferences is one important way to ensure that appropriate innovative technologies reach the most disadvantaged who are often otherwise 'left behind'. They summarised diverse papers that together pointed out that up to 40% of targeted beneficiaries adopt new seed varieties. Rates of varietal turnover, essential to combat biotic and abiotic stress conditions, leave a considerable potential yield gap unplugged. Mausch et al. (2021) highlighted the heterogeneity of demand among farming communities and the need for appropriate seed delivery systems to overcome this. Emphasis on regeneration of public-sector seed systems is needed because of the likely limitations of private seed distribution. Given the particularities of markets in Afghanistan, both the public sector and the private sector often fail to reach farming geographies that are remote and are not served by physical and institutional infrastructure. For many years up to the governance change of August 2021, many basic services and agricultural interventions have been provided by the NGO sector, and this form of delivery continues.

Increasingly challenging climatic conditions impact the breeding and distribution of effective and resilient varieties. Historically, people in the region deployed irrigation to manage climate extremes. From Bronze Age irrigation systems in northern Afghanistan (Luneau, 2019), through to systems of water management employed in the pre-modern period (Thomas & Kidd, 2017), water management has reached a considerable level of sophistication. Goes et al. (2017) acknowledge that the *karez* system in the Helmand Basin has suffered from considerable degradation. Rehabilitation, although expensive, could once again serve local farming in a way that supports stable agricultural production, restores Afghan heritage and rebuilds social cohesion. However, there are no easy solutions to the challenges of increasing irrigation to boost agriculture: Recent analysis by Mansfield on the changes to agriculture, water systems and livelihoods in south-west Afghanistan has shown how the introduction of solar-powered water pumps has led to both an intensification of agriculture (significantly, opium poppy) based on a level of extraction of deep groundwater that probably is unsustainable (Mansfield, 2020). Hence, it is also necessary to consider the potential contribution of rainfed (non-irrigated) wheat to building climate-resilient production. Although yields are lower, there is potential to optimise breeding specifically for rainfed production (e.g. through screening and selection for drought tolerance). We expect rainfed agriculture (and wheat) to continue given the limitations of water and infrastructure access, as well as potentially shifting cropping priorities in irrigated areas (e.g. to higher value crops).

3 | THE NECESSITY OF A MULTISECTORAL APPROACH TO WHEAT IMPROVEMENT

Wheat improvement must be embedded in the wider agricultural system, and in a deep understanding of social, political and cultural systems and how they vary between villages, and from districts, provinces and regions to people groups, and the respective roles of men and women in agriculture. Among the broader rural development considerations, it has been previously acknowledged (MAIL, 2013) that agricultural development in Afghanistan is reliant on multiple components. These include, but are unlikely limited to, improved access to markets, building of economies of scale among smallholders along with enhanced supply chain linkages, understanding the entry points and enabling increased participation of women in all socio-economic projects to ensure they address their concerns and needs and skills and capacity building to provide a stable foundation for the sustained eradication of poverty and food insecurity (GoIRA, 2019). All these elements are under-represented in current knowledge of wheat production systems and need to be systematically addressed in future (see Section 6).

Linked to the wider food system, a multidisciplinary and multisectoral approach is necessary in Afghanistan to encompass the downstream value chain issues in intermediary small to medium enterprise development (the missing or hidden middle of enterprise of Reardon, 2015 and Alibhai et al., 2017). The concept of an integrated, multidisciplinary wheat food system has recently been described, specifically highlighting the need for synthesis and alignment across agro-industries and the political economy and through to consumer science (Poole et al., 2021).

4 | A FORWARD RESEARCH AGENDA FOR ENHANCED WHEAT PRODUCTION IN AFGHANISTAN

4.1 | Collaborative programmes embracing diverse partners

Comprehensively enhancing wheat production in Afghanistan depends on expert international scientific support integrating the international research for agricultural development sector, including the Consultative Group on International Agricultural Research (CGIAR) research and breeding and United Nations (UN) system linkages (e.g. Food and Agriculture Organisation [FAO] and World Food Programme [WFP]). Given the constraints to public services delivery, public programmes must be integrated with both private sector initiatives and the (almost) omnipresence of (I)NGO-mediated rural programmes and services delivery. The immediate priority is development and delivery of improved seeds, addressing clearly defined market demands and supported to deliver productivity gains via use of appropriate agricultural infrastructure (Figure 1). Next, under evolving rainfall regimes, effective methods of soil and water management are needed urgently to manage and restore the natural resources base, especially in upland and mountain regions.

The diversity of Afghan geography, agriculture and peoples mean that different seed sub-sectors are necessary to serve different farming populations. New knowledge of the complexities of this wider seed distribution environment is necessary and will reveal the trade-offs that plant breeders, intermediary organisations, seed enterprises and farmers must make in upgrading the farmers' genetic resources.

4.2 | Building seed systems

Given the new varieties already present in the country, the current seed multiplication and distribution systems in Afghanistan are inadequate. According to Ataei (2021), plant breeding and seed distribution must be linked to a better understanding of farmers' seed management practices. Seed distribution is an integral function of genetic innovation linking plant breeding to enhanced agriculture. A 'seed system' is a more comprehensive phenomenon than the simple 'delivery' of a product to a farmer and constitutes part of wider agricultural innovation and knowledge management processes. Seed systems comprise the institutional architecture of formal public and non-governmental research systems and formal and informal enterprise. Seed systems are linked to the wider economy and the social and political contexts in which agricultural input markets function. The development of seed systems can often be linked also to short-term food aid and relief and to the investments of longer-term agricultural development programmes.

A new model of research dissemination and extension is required: with seed multiplication programmes connected to local farming systems and incorporating testing and quality control and external support to develop a coherent Afghan seeds programme. The efforts of the Kabul and provincial governments to boost agriculture need to be linked to the ongoing presence of (I)NGOs and the national distribution of research stations and universities. Together, these institutions offer the basis for effective seed system development. Likewise, formal breeding programmes need to be integrated with better knowledge of how farmers acquire seed through informal practices of seed distribution through saving, exchange and purchase. The interdependence between these component parts of the wheat system is highlighted in Figure 1.

A new public sector system for scaling up technologies is required to develop new seed materials. This should include knowledge media and mechanisms to select, assure, approve quality, produce and multiply the best varieties on a large scale in collaboration with local farming systems. Currently, there is no adequate extension system to disseminate research data to farmers, apart from the few efforts of some projects, highlighting their own limited achievements. Farmers' own preferences and needs should feed into research priorities through 'farmer first' approaches to rural development though improved communication channels operating between the periphery and the centre (Poole et al., 2018).

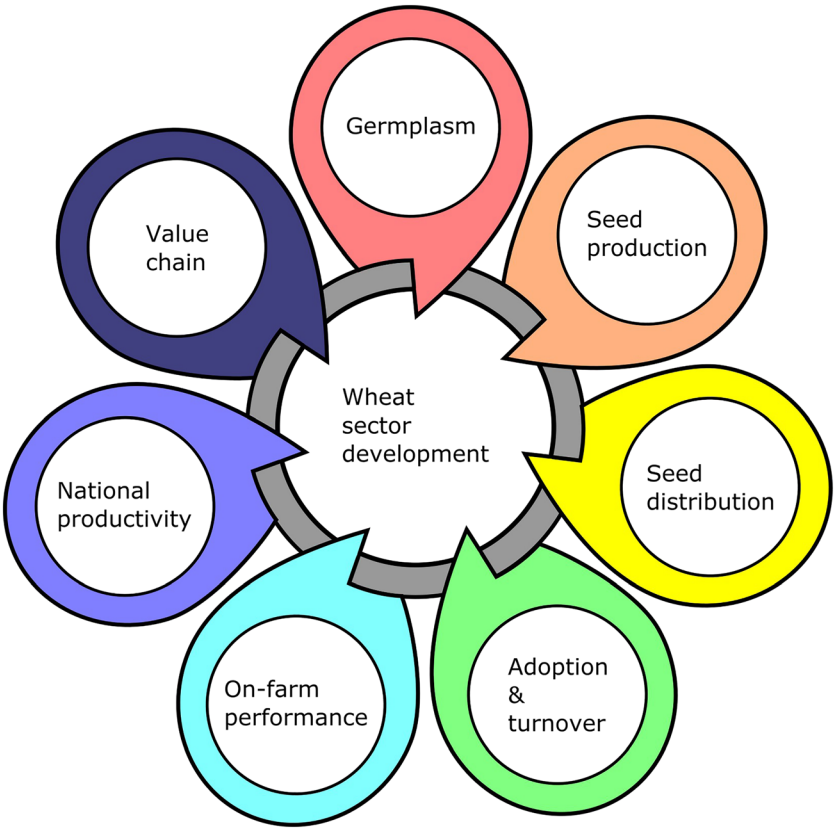

FIGURE 1 Development of Afghanistan's wheat sector will require an integrated programme of work that accounts for the interdependencies and feedback mechanisms. This encompasses breeding, seed and market sectors alongside farmer adoption leading to varietal turnover. Effects for on-farm and national productivity drive the value chain. All these components are linked either as parallel or complementary processes. In turn, progress in holistic wheat sector development will provide effective feedback into each of the components

Building seed multiplication capacity and seed quality control is a significant and medium-term challenge. This is related to the timely delivery of the high-quality seeds to farmers in adequate quantity and requires information, marketing and logistics solutions to overcome the barriers to uptake. These functions depend on the renewal of banking services and financial liquidity that have been largely frozen since August 2021. For sectoral knowledge generation and management, 'old' technologies such as radio, and new technology and methods such as mobile phones and citizen science engagement, offer unexplored research and outreach potential. Ultimately, seed must be affordable for poorer farmers and take into account the range of varieties for different end users. Above all, the improvements to physical security experienced in rural areas at the time of writing must be sustained.

4.3 | Tackling structural constraints

In addition, attention must be paid through research and extension to groups within and between farming populations who are excluded through structural imperfections. The imperfections in markets, weak governance and institutional capacity at both central and provincial levels in Afghanistan make market coordination particularly problematic (Poole et al., 2018). The analysis by Minoia and Pain (2017) of the intriguing methods of informal regulation of the onion market in Nangarhar, Afghanistan, explains the significance of the local social, economic and political structures that underlie, or undermine, the operation of Afghan agrifood markets, highlighting that context-specific interventions are needed in order to enable engagement in specific markets and locations (Minoia & Pain, 2017).

In order to address structural inequalities present in the prevailing production and distribution patterns of rainfed and irrigated wheat, it will be necessary for research to be conducted to assess the impacts of gender roles and patterns of labour and marketing. There is also a need to enhance knowledge about the dissemination of new technologies, for example, via assessment of the release, dissemination and adoption of improved, disease-resistant, high-performing wheat varieties through DNA fingerprinting (Dreisigacker et al., 2019) and identification of the management and distribution systems of local seed varieties.

4.4 | Including complementary agricultural services

In addition to biological and human components of the agricultural system, irrigation infrastructure, strategies and regulation must also be urgently addressed. As the report on the funding proposal for the Global Agricultural Food Security Program (GAFSP) noted, water management is key to agriculture and life in some districts of Afghanistan, also requiring crop and livelihood diversification to adapt to current and emerging climate realities (GoIRA, 2019). As noted earlier, indigenous technology such as the traditional *karez* system could once again serve local farming in a way to restore Afghan heritage and to rebuild social cohesion (Goes et al., 2017).

Accompanying technologies for irrigation and fertiliser usage are necessary to make best use of new seeds. For example, drawing on experience elsewhere, Keil et al. (2020) showed that zero tillage methods resulted in significant yield gains and cost savings for wheat farmers in Bihar State, India. There is also evidence from Central Asia that the introduction of conservation agriculture techniques can improve sustainability of diversified cropping systems rather than focusing on single crop production (Boboev et al., 2019). There is a need to develop and deploy innovative small farm cultivation machinery, particularly considering the often-hidden role of women in primary production. Participatory plant breeding methodologies can be effective when accompanied by sociological approaches to facilitate communication and engagement between multiple stakeholders and different scientific disciplines. These methods can be adapted in Afghanistan.

Sustainable systems will include linkages between the public sector/farmer-assisted R&D, appropriate regulation and commercial distribution of seeds and other technologies. Tahir et al. (2020) showed that for wheat production in Sudan, the innovation platform approach based on multi-stakeholder engagement, including technology demonstration, seed production, capacity strengthening and field-based extension activities significantly increased production and productivity. Again, this approach and other global experiences can be explored through South–South knowledge exchange, assessed and adapted for Afghanistan.

4.5 | Improving post-harvest and consumption practices

Further, there is need for improved post-harvest crop handling up to the consumers' final demand for prepared, satisfying and nutritious foods. Therefore, end-user nutritional requirements must be taken into account. The previous government's commitment to food fortification to enhance nutrition needs to be followed through, especially with respect to wheat flour (GAIN, 2018): Investment is needed in consumer science research to evaluate the phenomenon of local small-scale enterprise milling and how consumption preferences may differ from the large-scale grain storage, milling and processing sector. This will have implications on the effectiveness of wheat-based industrial food product formulation, fortification and distribution practices for better nutrition.

5 | BEYOND WHEAT, BEYOND AFGHANISTAN, BEYOND 2022

Accounting for 80% of cereal area and production, wheat is the most important but not the only component of Afghan agriculture and diets. Indeed, diversification would be advantageous to exploit diverse environments and market opportunities. Development of the wheat system must be conceived as a foundation for improvement of all plant breeding, seed multiplication, production technologies and input distribution, not just of wheat or even cereals, but other components of a diverse agricultural and horticultural production. This will serve wider interests as investment in the wheat system will spill over into other agricultural sectors. New agricultural structures and governance implemented under a new wheat programme will be synergistic with other sectors such as health and education. Due to the diversity of the target population of environments within Afghanistan, the new knowledge also has significant spillover potential for neighbouring countries in South and Central Asia and the Middle East.

The international community has spent trillions on security and many millions in Afghanistan on development from 2001 to 2021 (SIGAR, 2021). The future of Afghanistan will continue to affect other countries in the Eurasian region and the international community at large (Mohapatra, 2020). There is convincing logic in providing humanitarian and development aid into the future to tackle the long-term multisectoral development challenges, particularly food security (Poole et al., 2018; WFP, 2020). According to one report on the state of the population totalling about 38 million people:

> By late 2021, nearly half of Afghans were experiencing crisis or worse levels of food insecurity—the highest level ever recorded in Afghanistan and a 37% rise compared to six months earlier. Throughout early 2022, 55% of Afghans will face acute food insecurity, including nearly 9 million people at emergency levels—one step before famine conditions. Food insecurity is likely to deepen in 2022 as the country is facing shortages of food, rapidly rising food prices and an ongoing drought. Hunger may drive further displacement, as evidenced by IRC assessments in five provinces in mid-2021 that identified lack of food and livelihoods as the top reasons for people leaving their homes. (International Rescue Committee, 2022)

Given the chronic and acute conditions posed by environmental change (IPCC, 2019), the problems of human displacement are likely to extend beyond the region for the foreseeable future (IOM, 2021). Support to the agricultural economy will be essential, alongside other social sector supports (Cousins, 2021). Children are the most vulnerable, and the impacts of the prevailing level of hunger and malnutrition are likely to be felt for a generation or more (Himaz, 2018; Prendergast & Humphrey, 2014), imperilling the chances of achieving the Sustainable Development Goals for food security, nutrition and health.

6 | CURRENT STATUS, FUTURE PROSPECTS

Hard data about the current situation in Afghanistan are difficult or impossible to obtain. Following the government change, the withdrawal of donor supports and the implementation of financial restrictions have led to the closure of major donor-funded programmes and

projects that focused on agriculture and broader community development. These conditions have exacerbated unemployment and caused a loss of income among those who still have nominal employment.

The Food Security Information Network (FSIN) confirmed last year (2021) that aid organisations had already witnessed deepening humanitarian need (FSIN, 2021). The growing crisis in Ukraine is likely to amplify inequalities in the global food system (Bentley, 2022) and have most negative impact on import- and humanitarian aid-dependent countries including Afghanistan.

Nevertheless, there is anecdotal evidence of national and international organisations continuing to operate even under uncertain conditions. For a functioning and responsive agricultural sector in the country, there is need for a clear governance mechanism that so far is significantly weak in defining clearly the roles of and relations between Kabul and the provincial governance such as directorates and sub-directorates of agricultural departments. Clarifying structures and lines of communication will enhance the dynamic of knowledge management and relations between farmers, technical staff and researchers.

After combatting the current crises through humanitarian intervention, rebuilding the agricultural economy will necessarily be a major priority and will not happen without external support. The only way out of humanitarian food insecurity and the humanitarian crisis is for Afghans to once again grow sufficient food.

For agriculture and wheat, the resumption of farming will require significant investment. It is likely that many human resources essential for rebuilding agriculture have been dissipated or exiled. Nevertheless, there are experienced and credible (I)NGOs willing and able to operate humanitarian services. As of February 2022, local NGOs have secured agreement in most of the 34 provinces for women to work with women. In the remaining provinces, there is limited agreement for women to work in certain sectors, such as health and education. For the agricultural and rural development sectors, new agreements among local stakeholder organisations are envisaged. Additionally, the adoption of more flexible policies by the international community and donor organisations is necessary to build essential links to the new government.

7 | CONCLUSION

The development of quality wheat seed based on farmer and market needs and that seed delivered to farmers at the right time are essential stepping stones for future wheat production and food security in Afghanistan. In summary, the key elements of a new wheat program in Afghanistan are:

- Resumption of breeding of nutritious and climate-resilient varieties
- Optimisation of mechanisms for industrial fortification of wheat through large- and small-scale milling
- Development of a knowledge base on current *lacunae*, in particular, prevailing wheat production systems, gendered agricultural roles and farmer needs and preferences for varietal change
- Assessment and building of new knowledge on the dynamics of and potential policy support for input, output and financial markets in the agricultural sector
- Development of seed information systems using new technologies to enhance farmer engagement in research
- Expansion of knowledge on appropriate irrigation systems and development of nature-based solutions to protect soil and preserve/conserve water
- Investment in capacity building among all private, non-governmental, university and public stakeholders in seed systems and delivery
- Establishment of a wheat industry multistakeholder platform to align sectoral incentives and overcome common constraints
- Facilitation of inclusion of women in agricultural systems as a priority under the new government, given that enlightened policies will become implanted in society as time goes by

Combined, these foundations will support the regeneration of Afghanistan's agricultural sector and enhance food security, for which wheat is the principal component.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design: Nigel Poole, Rajiv Sharma, Najibeh Ataei and Alison R. Bentley; writing original draft: Nigel Poole; primary reviewing and editing: Rajiv Sharma, Najibeh Ataei and Alison R. Bentley; critical review and feedback: Orzala A Nemat, Richard Trenchard, Andrew Scanlon, Charles Davy and Jason Donovan; project administration and resources: Alison R. Bentley and Jason Donovan.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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