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Current Situation and Sustainable Development of Rice Cultivation and Production in Afghanistan

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Abstract: Poverty is a critical issue that is stagnating the development of Afghanistan. In 2007, more than 42% of the population of the country was reported as being below the poverty line, but until 2014, 78.2% of households even in the urban areas were still dealing with food shortages. The agriculture sector is the backbone of the country's economy and contributes as the key sector to the revival of the well-being of people in Afghanistan. Rice is the second staple crop after wheat and plays a key role in food security, nutrition, and caloric intake. However, Afghan farmers have suffered from the low quality of grains and yield which has resulted in the serious malnutrition which is occurring in the country. Insufficient breeding techniques for new rice cultivars with high yield and acceptable quality, mismanagement of agronomical practices, and unprogressive milling and processing thus can satisfy only 50% of the country's demand. Accordingly, Afghanistan has been compelled to import a huge annual amount of milled rice from Pakistan, India, and Iran. Although active efforts have been made by the government, research institutes, and international collaboration on rice research, production, and agricultural credits during the last 10 years, the deficit of milled rice in Afghanistan in 2018 is estimated to be 270,250 metric tons. This paper highlights the current situation of rice production in Afghanistan and suggests solutions for food security and sustainability in rice production to promote farmers' income, consequently strengthening the country's economy.

Keywords: rice; Afghanistan; cultivation; grain quality; poverty; processing; production; sustainability

1. Introduction

Approximately half of the Afghan economy depends on the agriculture sector. However, it is in a critical situation and needs urgent change for future growth, poverty reduction, and export growth [1]. Therefore, increased investments and an environment enabling agricultural production are required to strengthen the vigorous agricultural growth of the country. In 2005, the National Risk and Vulnerability Assessment (NRVA) indicated that agriculture and livestock provided the highest incomes to poor households. In 2007, the NRVA reported that 42% of the population of the country was below the poverty line [2], but in 2014, a total of 78.2% of urban households were still facing food shortages [3].

More than 80% of Afghans rely on agriculture-related activities for their livelihood [4]. There are approximately 8 million ha of arable land, of which 3.2 million ha are irrigated and 4.8 million ha are rainfed [5]. Cereal crops play the key roles in the diet of Afghans; among them, rice (*Oryza sativa* L.) is the second staple food after wheat [6]. Paddy rice yield achieved 2.8 metric tons per hectare in 2010, with a total of 190,000 ha of cultivated lands providing 532,000 metric tons of paddy rice or 319,200 metric tons of milled rice [6], while the average yield is higher in the neighboring country of Pakistan, which produces 3.5 metric tons per hectare of preferable quality for Afghan consumers [7].

Figure 1 shows the total cultivated area by paddy fields and total milled rice production from 1991 to 2017. Over this period, the population of the country rose to 36.65 million [8]; hence, the milled rice consumption per person annually was 17 kg in 2003 [9]. During 2015–2016, the milled rice production exceeded 33,600 metric tons, but 623,050 metric tons of milled rice are required for self-sufficiency. The current milled rice deficiency has resulted in the import of 270,250 metric tons annually from Pakistan, India, and Iran. Afghan rice consumers were strongly affected by the increase in the price of rice in Pakistan and India to 439 and 414 US $ per metric ton in 2017–2018, respectively [10].

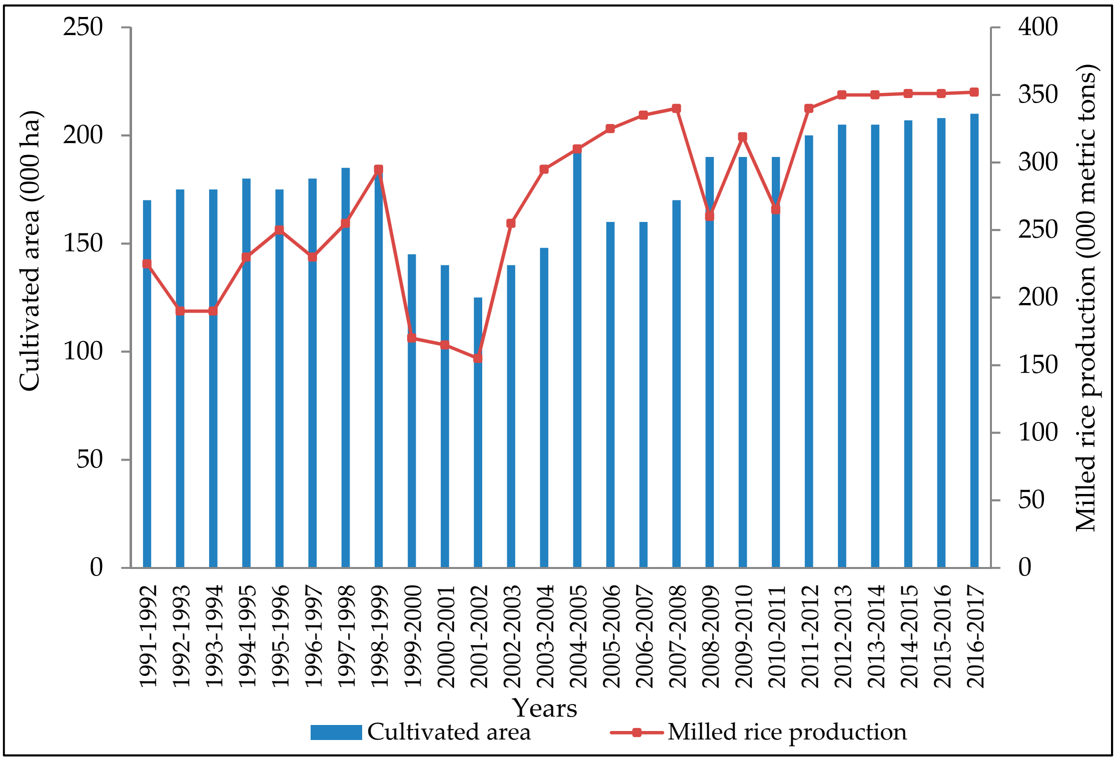

Figure 1. Total cultivated area of paddy rice and total milled rice production in Afghanistan from 1991 to 2017 [10].

On the other hand, local rice varieties have adaptation to local conditions, are low cost, and are resistant to pests and diseases, while their low genetic potential, unimproved cultivation systems, and processing management have caused their yield and quality performances to be low. At present, more than 90% of locally milled rice is produced based on manual processes; thus, it cannot compete with imported rice which has been undergone internationally acknowledged standards of milling and preservation [11]. Although the climate of Afghanistan is suitable for producing high-yield and -quality grains of rice, it is the lack of improving new rice cultivars, professional assistance, appropriate cultivation systems, and advanced milling, processing, and preservation technologies which attribute to the low yield and quality of rice grains [12].

This study aims to address the problems and challenges in rice cultivation, production, and processing aspects, as well as the future prospectus for rice production in Afghanistan toward sustainable agricultural production.

2. Data Collection and Method

Data relevant to rice production in Afghanistan were collected from available information on the Internet, in scientific books, and in journals. Data on the growth characteristics of rice and production quantities in different provinces and whole countries were collected from Ministry of Agriculture, Irrigation and Livestock of Afghanistan (MAIL), Directorate of Agriculture, Irrigation and Livestock (DAIL) in Nangarhar province, and Shesham Bagh Research Station during the period of October 2016 to August 2017.

Comprehensive and well-structured questionnaires in the English language were distributed to the academic staff of agriculture faculties in the northeastern and eastern zones, including Takhar, Kunduz, Laghman, Nangarhar, and Kunarha provinces; rice milling factories; farmers who had planted rice in their fields; traders; and consumers. Data were collected on farm size, seed sources, varietal differences, inputs, cultivation methods, agronomic practices, processing techniques, major rice pests, disease and weeds, general problems, and challenges in rice production. A sample size of 50 respondents was selected through random sampling. Comprehensive information was obtained through face-to-face interview with farmers in local languages (Pashto and Dari). Collected data were then arranged and analyzed with Tukey's test using SPSS 13.0 statistical analysis software (Prentice Hall, New Jersey, NJ, United State).

3. Results

3.1. Rice Cultivation Management

The majority of paddy fields are located in the northern, eastern, and western regions of Afghanistan, depending on water availability. The top producing provinces, which together account for 85% of the country's rice production, are Baghlan, Kunduz, Takhar, Laghman, Herat, Nangarhar, Balkh, and Kunarha [13]. The total cultivated area and overall production quantity of each province are listed in Table 1. In Afghanistan, rice is commonly grown at 1000–3000 feet above sea level, though it is sporadically cultivated at >6000 feet elevation [14]. Rice plants take approximately 110–160 days from planting to harvesting, depending on cultivars and field locations. The planting period for rice cultivation starts from March–April, transplanting from May–June, and harvesting at the end of October, but this varies among cultivars and regions.

Afghan farmers principally grow paddy rice by hand transplanting. Rice seedlings are provided from their own plants, neighbors, the local market, or agricultural organizations. Paddy fields are plowed using animal forces, although tractors are used in some areas [15]. At first, seed bags are put into the water for around 2–3 days for pre-germination. The pre-germinated seeds are sown in prepared nursery beds (made of paddy mud), and finally, 30–40-day-old seedlings are transplanted into the paddy fields by hand.

The average yield of rice in Afghanistan is 2.8 tons per ha. For fertilizers, rice plants commonly require around 76 kg nitrogen and 46 kg phosphorus (as P_2O_5) per hectare, but the fertilization rates are dependent on natural soil fertility [16]. Soils in Afghanistan are rich in mica minerals (source of K_2O); thus, potassium fertilizers are rarely applied.

Recently, farmers have been applying the System of Rice Intensification (SRI) as a water-saving method in northeastern Afghanistan. Their SRI average yield, 9.3 ton per ha, is remarkably higher than that obtained from traditional practices [16].

Table 1. Top rice-producing provinces in Afghanistan, their total cultivated areas, and paddy rice production quantity.

Provinces	Location (zones)	Cultivated Area (ha)	Production (tons)	Av Yield (ton ha^{-1})
Baghlan	North Eastern	32,196	105,525	3.28 ^{e}
Kunduz	North Eastern	40,210	100,835	2.51 ^{h}
Takhar	North Eastern	35,532	51,590	1.45 ^{i}
Laghman	Eastern	9655	37,520	3.89 ^{d}
Heart	Western	7000	33,299	4.76 ^{b}
Nangarhar	Eastern	6371	30,485	4.78 ^{a}
Balkh	North Western	8000	24,623	3.08 ^{f}
Kunarha	North Eastern	4725	18,760	3.97 ^{c}
Total		143,689	402,637	2.80 ^{g}

Source: Afghanistan Statistical Yearbook, 2010 [6]. Different letters in a column mean significant difference at a 5% probability level.

Weeds, diseases, and pests are the major constraints in the rice cultivation and storage period. Jungle rice (*Echinochloa colona* (L.) Link), bog bulrush (*Schoenoplectus mucronatus* (L.) Palla), and Bermuda grass (*Cynodon dactylon* (L.) Pers.) are the most problematic weeds in paddy fields [17]. Rice blast, stripe rust, stem rot, and false smut are the most detrimental diseases. In addition, grasshoppers, birds, and snails are reported as the major pests [18]. There is a lack of information related to the scale of losses caused by weeds, diseases, and pests in the field periods. Based on the reports from the plant protection and quarantine department of MAIL (PPQD), significant losses due to storage pests such as the flour beetle (*Tribolium castaneum*) and seed beetle (*Cryeadon cerratus*) are estimated at more than 30% of rice grains [19].

The traditional methods such as the burning of old crops, weeding and uprooting of weeds, crop rotation, selection of healthy seeds, etc., are mostly conducted to control weeds, diseases, and pests, whereas chemical methods are applied without ensuring safety and standard roles. Conventionally, hand-weeding is also carried out twice during the rice growing season: 15 days after transplanting and again 2 weeks after the first weeding.

3.2. Rice Processing Management

In Afghanistan, rice plants are cut down in fields with hand sickles and stocked in windrows. After they are air-dried, they are moved to large stocks and then threshed by teams of oxen or infrequently by animals to separate straw from grains. This is a rather inefficient method, as a large number of grains is lost during the threshing process [15]. In some villages, milling operated by tractors is used to separate grains and straw with much better efficacy. The threshed grains are de-husked by mills (water-driven or tractors) to remove husks. In water-driven mills, water is forced into a narrow channel to get sufficient force to operate the rather bulky and unwieldy de-husking devices. Some farmers apply a par-boiling procedure ahead of milling to enhance the milled rice quality. After removing chaff and dust, rice grains are air-dried and stored in bags or big jars or directly supplied to local or city markets.

In recent years, milling factories have started offering processing and supply services with better quality and good packing facilities. Rice grains are processed in three phases (par-boiling, drying, and processing). The par-boiling phase includes cleaning, grain socking, and steaming. After drying, the processing phase consists of de-husking, polishing, grading, cleaning, and packing. Farmers bring their paddy grains to nearby factories to sell or process. Commonly, 80 kg of paddy grains provides 40 kg of milled rice. Milled rice is packed into either 25 or 50 kg bags and supplied to markets. The by-products such as rice husks, rice bran powder, and broken grains are used in poultry and fish farms, whereas ash is used in agricultural fields to enhance soil fertility. However, milling factories are faced with a shortage of advanced machinery, professional staff, and international-standard packing systems [20].

3.3. Rice Genotype Parameters

Table 2 shows the major local and improved rice cultivars in Afghanistan with their growth and yield characteristics. There are two types of rice cultivars, ''Loke" (short grain, thick, and high stickiness) and ''Ma-een" (long grain, thin, and low stickiness), which are differentiated based on grain size, color, consistency, stickiness, and distribution [21].

Afghan farmers and processors have not yet addressed rice grain quality during the cultivation and processing periods. Therefore, the market value of domestic rice grains is low, and consumers prefer imported rice grains from neighboring countries which have higher processing and cooking qualities.

Table 2. Principal local and improved rice cultivars in Afghanistan and their growth characteristics.

Cultivars	Type	Maturity	GP	Group	Origin	DH	Paddy Yield (t/ha)
Shishambagh-14	Improved	Moderate	140	Short	India	110	8.5
Garma Ghati Japani	Improved	Moderate	130	Short	Japan	103	6.5
Zodrass	Improved	Moderate	128	short	India	103	8.2
Surkha Zerati	Local	Moderate	130	Short	India	106	5.2
Sarda Behsoodi	Local	Late	142	Short	Japan	114	5.8
Kormaki Ghati	Local	Late	142	Short	India	123	6.0
Sarda Barah	Local	Late	142	Short	India	114	4.5
Lawangi	Local	Late	142	Short	Korea	117	4.2
Garma Behsoodi	Local	Late	142	Short	Japan	124	6.0
Nezam Ghati	Local	Late	142	Short	India	125	5.5
Kunduz No. 1	Improved	Early	113	Medium	India	86	7.0
Jalalabad-14	Improved	Moderate	140	Medium	Indica	110	8.5
Manjoti	Local	Late	149	Medium	India	117	6.5
Sela Panjabi	Improved	Early	113	Long	Pakistan	88	6.8
IR 28	Improved	Early	113	Long	Philippines	91	5.8
IR 2016	Improved	Early	113	Long	Philippines	93	5.5
IR 22	Improved	Moderate	124	Long	Philippines	101	5.5
Attai-1	Improved	Late	145	Long	Indica	115	8.0
Super Basmati	Local	Late	149	Long	India	136	7.0

This list of local and improved rice cultivars was prepared based on interviews with the staff of the Directorate of Agriculture, Irrigation and Livestock (DAIL) and Shesham Bagh research station. GP: growth period, DH: days to heading.

3.4. Challenges in Rice Cultivation and Production

The organizations responsible, such as the Ministry of Agriculture, Irrigation, and Livestock of Afghanistan (MAIL) and the Central Statistics Organization (CSO), are hindered by the lack of scientific and reliable data in establishing a comprehensive baseline for rice production, marketing, and consumption.

The principal problems are the shortfall of professional personnel, basic and applied research, improved breeding seeds, cooperative systems, credit facilities, and agricultural machinery. The poor strength of the farmers' economy; small-scale farms; irregular application and low quality of fertilizers; mismanagement of pests, diseases, and weeds; water shortage; low milling, packing, and storage qualities; and marketing availability are the present challenges in rice as well as general agricultural production in Afghanistan.

Paddy rice is grown in lowlands as well as flooded basins on small-scale farms; however, land strategies and leveling practices may allow larger basins in the near future. Most of the rice seeds used in Afghanistan are a local type which has low yield and is susceptible to diseases and pests. Only a few improved rice varieties have been imported [10]. These varieties have better quality and yield than the local cultivars, but rice scientists need to breed novel cultivars to reduce the dependency on foreign rice varieties.

Beside professional personnel, appropriate farms, and cultivation systems, high productivity depends upon access to agricultural cooperatives which can support farmers in getting high-quality inputs such as seeds, fertilizers, pesticides, and machinery. Afghan farmers suffer from a lack of machinery and technologies, and they mostly deal with traditional equipment. Such a condition has caused time inefficiency, low productivity, and food scarcity.

Farmers have relied solely on chemical fertilizer application as a rice yield enhancer, but they do not care about soil quality or the application of organic fertilizers. Although micronutrient supply and management has never been considered for increased productivity, imported chemical fertilizers from Pakistan and China including nitrogen and phosphorus are available in markets and are used depending on the region and the economic condition of farmers [22].

Storage and marketing factors are also the dominant threats for Afghan farmers as they do not have acceptable value in markets yet because of primitive techniques in milling, processing, and packing. The losses of grains in the post-harvest and milling periods account for 10% and 30% of the total yield, respectively [10].

4. Discussion

4.1. Current Potential of Rice Production

Based on the data obtained from the survey, it is shown that Afghanistan has the potential to increase its rice yield within a short term. The majority of farmers select self-produced seeds for future cultivation (Figure 2). Several kinds of research were conducted on the adaptation and evaluation of new high-yielding cultivars [23]. The government should lead the way in the distribution of improved rice cultivars to farmers throughout the country. To achieve the above target, research stations, DAIL, and MAIL, with the collaboration of private seed enterprises, must point out high-yielding and well-adapted rice cultivars based on regions and the increased production level of improved seeds. Such seeds can be distributed at subsidized prices which will lead to the dependency of private seed enterprises on MAIL's procurement system and will decrease the input cost.

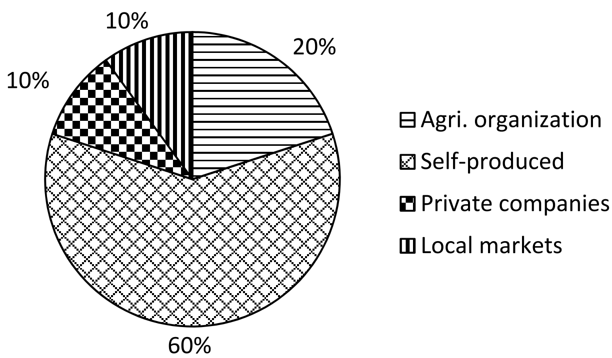

Figure 2. Seed sources for current cultivation throughout the country, 2017 [23].

Rice productivity and quality traits are mostly related to the cultivation system and agronomic practices [24]. Several types of research have been conducted to point out the best agronomical practices at the provincial level. Moreover, Japanese experts assembled advanced techniques for cultural practices in terms of seed selection, row planting, weeding, fertilizer application, irrigation management, harvesting, etc. Farmers do not manage planting density and number of seedlings per hill, though these play a crucial role in productivity. Previous findings indicated that a 15 $\times$ 20 cm planting density and 3 seedlings per hill is suitable for rice cultivation [25]. Therefore, it is necessary to have a linkage between research stations, extension workers, and farmers through demonstration plots, farmer field school, training, and workshops.

As mentioned above, Afghan farmers' work suffers from a lack of machinery. There are some types of machinery in the provincial departments of MAIL which were introduced by related donor organizations but which need serious attention. Such a situation causes a decline in cultivation efficiency; therefore, it is necessary to facilitate transplanting, weeding, and harvesting machinery which will lead the way for row cropping and increase harvesting efficiency.

The low quality of pesticides and fertilizers has resulted in insufficient pest control and soil fertility; hence, the department of plant protection and quarantine should be reactivated to ensure quality. The marketing of hazardous, substandard, and unreliable pesticides and fertilizers should be banned to decrease the risk of introduced and quarantined pests and improve fertilizer quality.

Afghan millers are bearing the burdens of insufficient local rice production, unreliable electricity supply, and security problems. Such conditions, as well as the imported rice price, do not allow the mills to reach their full capacity and discourage the growth of commercial milling activities. Milling factories should be supported to increase their capacity and productivity for better quality. Overcoming the above problems will lead the milling factories to be one of the country's most promising industries. Thus, the subsidized price will encourage milling factories and decrease the effects of competition from neighboring countries.

The upshot of the above is that a production system with suitable and quality inputs, improved agronomical practices, advanced machinery, and processing management can increase farmers' income by way of improved potential yield and quality of grain, consequently leading the way for sustainable and continual rice production in Afghanistan.

4.2. Future Prospects in Rice Production

Afghanistan has undertaken a program to establish Agricultural and Rural Development Zones (ARDZ) to expand commercial activities, enhance agricultural productivity, and create job opportunities in rural areas, as well as to develop agro-based export potential [2]. In Afghanistan, agricultural prospects are predicted to be largely dependent on private organizations, as they can speedily and effectively respond to challenges, but need to be supported by the government [1].

Over the past decades, the area of rice cultivation has been expanded [26]. The increase in rice consumption is proportional to the growth of the country's population (Figure 3). Recently, technical improvements such as the enhancement of research capacity, activation of extension systems, and collaboration between research and extension work in rice cultivation and production to increase rice yield and grain quality have been attracting attention.

New technical and practical information and assistance in terms of seed selection and pre-treatments; nursery bed and field preparations; row planting systems; irrigation; weed, disease, and pest management; pre- and post-harvest handlings; etc., have been shared with farmers from national and international organizations through dispatched and collaborated research, technical assistance, demonstration plots, and extension workers [27]. Such techniques were adopted without using large-scale machinery and heavy inputs, and farmers with small-scale farms can apply them.

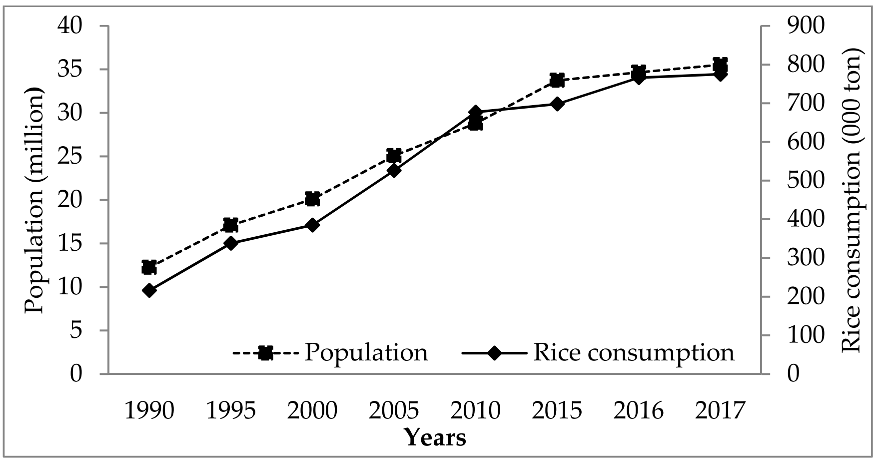

Figure 3. Rice consumption and population density in Afghanistan during 1990–2017 [8,28].

Early this decade, Afghanistan requested from international donors, especially the government of Japan, technical cooperation projects in agricultural development, among which the improvement of the productivity and quality of rice in Afghanistan was the priority. The Japan International Cooperation Agency (JICA) designated 3 million US $ to a project to develop rice production in the three eastern provinces of Nangarhar, Laghman, and Kunarha [29]. This project was to improve agricultural productivity exclusively in rice through the enrichment of research and extension activities. A laboratory was built by JICA for rice research and variety identification. It has certified 22 varieties of rice (Afghan, Indian, and Japanese) for cultivation since 2009 [30].

International donors have been asked to rebuild and develop the agriculture sector through funding the Afghanistan National Development Strategy (ANDS). The country has vast arable land, fertile soil, and adequate water resources; therefore, it has a strong potential to become self-sufficient in food and other agricultural outputs. However, combating drought through an improved irrigation system is a principal challenge [28]. The available but out-of-date irrigation systems have wasted much water and caused water scarcity, thus seriously affecting sustainable crop production in Afghanistan. In 2015, around 7500 ha of paddy fields were planned for cultivation in Herat province, but only 3500 ha were harvested because of drought. Recently, the Salma Dam was constructed to provide water for the Herat province and other areas. As a result, the area of land cultivated as paddies jumped to 14,000 ha in 2016 [10].

The On-Farm Water Management Project (OFWMP) improves agricultural productivity by enhancing the efficient use of water. The key project indicators include land and water productivity and the percentage increase in irrigated area [31]. Several efforts were made by the Cornell International Institute for Food, Agriculture and Development (CIIFAD) from 2003 onward to install System of Rice Intensification (SRI) methods in Balkh province. The Aga Khan Foundation (AKF) then began working with SRI methods. Since 2009, it has introduced successful research trials to primary provinces having large paddy-filled areas [26].

Afghanistan has also carried out a new strategic plan for promoting and enhancing rice productivity to achieve to self-sufficient rice provision [15]. Yields of paddy rice were targeted to reach 6.5 tons per hectare through the adoption of new technologies and improved production practices. The National Rice Promotion Strategy (NRPS) implemented >900 field trials in 2016 across the country to examine new technologies for rice growers, and similar trials have been conducted in subsequent years. The Rice Private Sector (RPS) was established and connected with procurement authorities within the country.

Afghanistan has set a target to produce 935,000 metric tons of paddy rice by 2021 to satisfy the national demands of 610,000 metric tons and to export 60,000 metric tons of milled rice, especially rice produced in northern and eastern provinces of Afghanistan which has received favor from the markets of central Asian countries [10]. To help farmers access credit, NRPS has called for loans to individual farmers, rice growers' associations, and cooperatives to enable farmers to obtain machinery for agronomical practices and harvesting operations. On the other hand, processing facilities aside from the available commercial milling factories in the country can acquire machinery through loans with easy repayments to improve the productivity of rice growers in Afghanistan.

5. Conclusions

In 2018, the deficit of milled rice in Afghanistan is estimated to have been about 270,250 metric tons. Although the climate of Afghanistan is favorable for rice cultivation and production, the lack of improved seeds, cultivation systems, appropriate technologies, suitable irrigation systems, post-harvest handling, and processing management resulted in rice grains in low yield and unacceptable quality. In contrast, a massive amount of rice grains is being imported from Pakistan, India, and Iran to fulfill the requirements of rice consumption throughout the country.

The introduction of high-yielding rice cultivars, adaptation of new techniques, cooperative systems, credit access, and the use of demonstration farms may assist the dissemination of improved rice cultivation techniques in the main cultivating provinces and to neighboring areas in the future. Therefore, the provision of opportunities for collaboration between the research and extension sectors and affordable access for farmers to quality inputs and services are indispensable to increasing rice productivity and grain quality, thus enhancing the income of rice farmers. Without developing strong mitigation strategies to tackle the problems faced by milling factories and storage facilities, they will continue to underperform and run at a loss. In addition, a marketing approach is required to benefit farmers through increased competitiveness with imported rice.

This paper highlighted the best input management practices and internalized problem solutions for rice production and suggested that active measures by the government, rice research institutes, agricultural agencies, and international collaboration could apparently establish sustainable rice production in Afghanistan in order to pursue self-sufficient provision, allow export in the next several years, and ensure food security.

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