Chapter 1

Status and Outlook of Global Food Security and the Role of Underutilized Food Resources: Sago Palm

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Abstract The United Nations (FAO) projected that global food production needs to be increased by 60% by 2050 to meet increasing world demands as a result of rapid population growth and per capita food consumption increase. However, there is a very little room to expand agricultural land, while water scarcity is threatening future agricultural production potential. Under the circumstances, it is predicted that nearly 90% of the food production increase should come from existing arable land through yield increase and advancement of agricultural research and innovation. On the other hand, the world is facing other serious challenges and uncertainties resulting from the stagnation of productivity growth of major cereal crops, advancement of negative impacts of climate change, and competition on the use of agricultural land and water with bioenergy crops. It is uncertain if and whether the world can meet the challenging target by 2050. Otherwise, the world food security, peace, and stability would be seriously threatened. The situation sparked scientific interest in identifying alternative food resources, which can be grown on underutilized lands without or with less competition with existing food crops, tolerant to stress environmental conditions, and produce a substantial quantity of food or starch. FAO recognized that neglected and underutilized species play a crucial role in the fight against hunger and are a key resource for agriculture and rural development for the benefit of smallholder farmers. In addition, many neglected and underutilized species play a role in keeping cultural diversity alive. They occupy important niches, conserving traditional landscape, adapted to the risky and fragile conditions of rural communities.

Against this backdrop, sago palm (*Metroxylon sagu* Rottb.) was identified as one of the most promising typical underutilized food crops with very little attention and research in the past. It can be grown in underutilized wetlands and peat swamps where other food crops cannot grow economically. It produces a high yield of edible starch (about 150–300 kg of dry starch per plant), while different parts of the palm

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tree can be utilized as roofing materials, animal feeds, sago worm production, mat and basket weaving, etc., which would contribute to promoting national and household food security and enhancing family income and employment generation at rural villages.

1.1 Present Status of Global Food Production and Food Security

At present, as estimated by FAO, the world produces more or less sufficient food to meet the needs of world population and maintains sufficient food stock to cover nearly 25% of estimated annual utilization. Despite the positive situation on the supply side, FAO's estimation in 2014–2016 indicated that, globally, 795 million people were unable to meet their dietary energy requirements. Thus, around one in nine people in the world is suffering from chronic hunger and does not have sufficient nutritionally balanced food for an active and healthy life. The vast majority of these undernourished and chronically hungry people live in developing world (FAO 2015).

While at the global level, there has been an overall reduction in the number of undernourished people between 1990/1992 and 2014/2016 (Fig. 1.1), different rates of progress across the regions have led to change in the distribution of undernourished people in the world. Most of the world's undernourished people are still found in Southern Asia, closely followed by sub-Saharan Africa and Eastern Asia. Asia is a home of nearly two thirds (63%) of the total undernourished population (FAO 2015).

Fig. 1.1 Status of world chronic hunger population (FAO 2015)

1.2 Future Outlook Toward 2050

1.2.1 Population and Consumption Increase

The questions are what is the food requirement to meet the needs of growing population and what is the future prospect of the production and challenges to ensure food security for our children and future generations. One of the current UN projections indicates that world population could increase by more than 2 billion people from today’s level, reaching around 9.3 billion by 2050 (Fig. 1.2). Incomes and per capita calorie intake will grow even faster. According to FAO’s estimate, by 2050, some 52% of the world’s population may live in countries where average calorie intake is more than 3000 kcal/person/day, while the number of people living in countries with an average below 2500 kcal may fall from 2.3 billion to 240 million (FAO 2015).

1.2.2 World Needs 60% Food Production Increase by 2050

To meet rapidly increasing combined food demand from both population growth and per capita food consumption increase, FAO projects that global agricultural production in 2050 would have to be 60% higher than that of in 2005/2007 if the world is going to satisfy food requirement at that time (FAO 2012a).

Fig. 1.2 World population trends (Source: UN)

Fig. 1.3 Sources of production growth from 2005/2007 to 2050 (FAO 2012b)

1.2.3 *Agricultural Research Is the Key for Achieving Future Food Security*

According to a FAO study, most of the increase in production (nearly 90%) leading up the year 2050 (from 2005/2007 to 2050) is expected to derive from improved yields through agricultural research (Fig. 1.3). Some gains would also come from higher cropping intensity, predominantly in developed countries (FAO 2012b), and about 5% increase (70 million ha) from the expansion of arable land, mainly from developing countries in Africa and Latin America (FAO 2012b).

1.3 Future Challenges and Uncertainties

While it might be possible to increase food production by 60% by 2050 if the above assumptions and prerequisites are met, there would be a number of serious challenges and uncertainties as explained below.

1.3.1 *Stagnation of the Increase of Arable Lands*

Globally, expansion of arable land could be stagnated. Land under crops is projected to increase only by some 70 million ha (about 5% increase from the level in 2005/2007) by 2050 (Fig. 1.4). As much of the spare land is concentrated in a small number of countries, constraints may be very pronounced in other countries and regions. Where these constraints are coupled with fast population growth and inadequate income opportunities, land scarcity can lead to more poverty and migration.

Fig. 1.4 Limited scope for the expansion of arable lands (FAO 2012b)

Thus, local resource scarcities are likely to remain a significant constraint in the quest for achieving food security for all (FAO 2012b).

1.3.2 Water Scarcity

Water is another critical resource, and irrigation has played a strong role in contributing to past yield and production growth. The world area under irrigation has doubled since the 1960s to 300 million ha, but the potential for further expansion is very limited. Water resources are extremely scarce in the Near East and North Africa and in northern China, where they are most needed. A net increase of 20 million ha of irrigated area (only about 7% increase from the level in 2005/2007) is expected by 2050 (FAO WAT 2030/2050, 2012, Summary). On the other hand, the agriculture sector occupies about 70% of total water use. If food production is to be increased by 60%, there would be need of a large quantity of additional water for food production in the future, when water scarcity would be taking place at the same time.

1.3.3 Stagnation of Productivity Growth

Annual productivity growth rate of main cereals, especially wheat and rice, declined (or expected to decline) sharply in past decade and will decline in future (2005–2050) to 0.8% (wheat) and 0.6% (rice) if compared with that of 2.9% and 1.9%, respectively, during the Green Revolution period and beyond starting in 1961 till

Fig. 1.5 Change in annual productivity growth of major cereals between 1961–2007 and 2005–2050 (Source: FAO)

2007 (Fig. 1.5). This might be attributed partly to a sharp decline in agricultural investment (especially for agricultural research and development) that recorded the decline in annual growth rate from more than 6% during 1976–1981 to less than 2% during 1991–2000 in developing countries (FAO 2012a).

1.3.4 Uncertainties: Bioenergy and the Impact of Climate Change

The international price of crude oil has been fluctuating significantly and became very volatile in the recent past. Significant changes in energy prices would potentially divert commodities and land/water to renewable energy production, which would result in increased use of food grains for biofuel production, and higher competition on the use of land and water between food crops and bioenergy crops. Moreover, the impact of climate change is not yet fully understood (FAO 2012b), and there is a great risk that climate change might increase extreme weather events, such as floods and droughts, and might negatively affect food production. Estimated rise of sea water level and surface temperature, as a consequence of global warming, might also result in deduction of agricultural land especially in fertile delta and lowland areas, outbreak of new plant pests and animal diseases, and change in cropping patterns and productivity growth. While actual impacts of climate change to future food production are yet to be known at this stage, there are great uncertainties and high risks associated with climate change on future global food security.

1.4 Value of Underutilized Food Crops Toward Promotion of Biodiversity, Food Production, and Food Security

1.4.1 Biodiversity and Food Security

Biodiversity for food and agriculture includes the components of biological diversity that are essential for feeding human populations and improving the quality of life. It includes the variety and variability of ecosystems, animals, plants and micro-organisms, at the genetic, species, and ecosystem levels, which are necessary to sustain human life as well as the key functions of ecosystems according to FAO (<http://www.fao.org/biodiversity/group/en/>).

Such diversity is the result of thousands of years of farmers' and breeders' activities, land and forest utilization, and fisheries and aquaculture activities combined with millions of years of natural selection. Most of the human population lives in areas where food production and nature coexist.

The conservation and sustainable use of biodiversity for food and agriculture play a critical role in the fight against hunger, by ensuring environmental sustainability while increasing food and agriculture production. It is imperative to do so in a sustainable way: harvesting resources without compromising the natural capital, including biodiversity and ecosystem services, and capitalizing on biological processes.

To cope with future challenges and uncertainties in global food security, a large reservoir of genetic and species diversity will need to be maintained and sustainably used. This diversity will further help maintain and rehabilitate productive ecosystems to supply future generations with abundant food and agriculture according to FAO (<http://www.fao.org/biodiversity/group/en/>).

Despite the importance of biodiversity as outlined above, the declining number of species, upon which food security and economic growth depend, has placed the future supply of food and rural incomes at risk. The shrinking portfolio of species and varieties used in agriculture reduces the ability of farmers to adapt to ecosystem changes, new environments, needs, and opportunities.

About 7000 species of plants have been cultivated for consumption in human history. The great diversity of varieties resulting from human and ecosystem interaction guaranteed food for the survival and development of human populations throughout the world in spite of pests, diseases, climate fluctuations, droughts, and other unexpected environmental events. Presently, only about 30 crops provide 95% of human food energy needs, four of which (rice, wheat, maize, and potato) are responsible for more than 60% of our energy intake. Due to the dependency on this relatively small number of crops for global food security, it will be crucial to maintain a high genetic diversity to deal with increasing environmental stress and to provide farmers and researchers with opportunities to breed for crops that can be cultivated under unfavorable conditions, such as drylands, wetlands, swamps, and saline soils, and tolerant to extreme weather conditions according to FAO (<http://www.fao.org/biodiversity/group/en/>).

1.4.2 Uncertainty in Future Food Security

As outlined in the above Sects. 1.2 and 1.3, the world population is expected to grow further and would reach around 9.3 billion by the year 2050 with increasing per capita calorie consumption. FAO estimates that the global food production has to be increased by 60% during the period between 2005/2007 and 2050 to meet the increasing demands, out of which nearly 90% is expected to come from existing arable land through yield increase as there is a very little potential to expand arable land in the future. This goal has to be achieved under various constraints and uncertainties such as decline of annual productivity growth rate of major staple foods, increasing water scarcity, advancing negative impacts of climate change and natural disasters, and rapidly increasing competition between food crops and bioenergy crops on the use of land and water resources. Consequently, there has been growing global concern of the serious food security challenges and uncertainties in coming decades, which may further impact world peace and stability, if sufficient foods are not produced to satisfy future global needs, especially for poor people in food-deficit countries. There is an urgent need to advance agricultural research and maximize the effective use of land resources for food production. On the other hand, globalization has created homogeneity of food resources, accompanied by a loss of different culinary traditions and agricultural biodiversity, and created negative consequences for ecosystems, food diversity, and health. Accordingly, FAO has stressed the importance of neglected and underutilized species, which would play a crucial role in the fight against hunger, and called for increased research on underutilized food resources especially those produced on poor and underutilized lands (wetlands, swamps, saline soil, etc.) by the poor. The situation has sparked interests in identifying underutilized alternative crops for food use.

1.4.3 Value of Underutilized Food Crops and Sago Palm

Many neglected and underutilized species are adapted to low-input agriculture. The use of these species – whether wild, managed, or cultivated – can have immediate consequences on the food security and well-being of the poor. Dr. Graziano da Silva, the Director-General of FAO, stressed at an international seminar held in Spain in December 2012 that neglected and underutilized species play a crucial role in the fight against hunger and are a key resource for agriculture and rural development. He called for increasing research on underutilized crops for the benefit of smallholder farmers. In addition, many neglected and underutilized species play a role in keeping cultural diversity alive. They occupy important niches, conserving traditional landscape, adapted to the risky and fragile conditions of rural communities (FAO 2012b).

Sago palm (*Metroxylon sagu* Rottb.) is one of the typical underutilized indigenous food crops in Asia and the Pacific Region, with very little attention and research in the past. It can be grown in underutilized wetlands and peat swamps where other

food crops cannot be grown economically and produce high yields of starch (150–300 kg of dry starch per plant). Thus, sago palm has a high potential to contribute to food security as an additional source of staple foods without (or less) competition on the use of arable land with other food crops, as well as for other industrial use including bioplastic and bioethanol production. Sago palm is grown in Indonesia, Papua New Guinea, Malaysia, Thailand, the Philippines, Timor-Leste, Pacific Island countries, etc. Despite playing an important role as a source of traditional foods, and off-farm and nonfarm income generation of poor rural communities, the sago palm population has drastically decreased in the recent past due to the conversion of sago-growing wetlands and swamps for other purposes including for the expansion of industrial crops such as oil palm and rubber trees.

1.5 Role of Underutilized Food Resources: Sago Palm and Its Economic, Social, and Environmental Benefit

Against the background outlined in the earlier sections above, and in view of the fact that it produces high yield of starch and grows in underutilized wetlands and swamps, sago palm was identified as one of the most promising underutilized food resources with a high potential for its contribution to global food security.

1.5.1 Sago Palm (*Metroxylon sagu* Rottb.): General Introduction

Sago palm (*Metroxylon sagu* Rottb.) is a species of the genus *Metroxylon* belonging to the Palmae family and is a socioeconomically important crop in Southeast Asia. It grows well in humid tropical lowlands, up to an elevation of 700 m, and is a source of starch and offers considerable potential to contribute to food security where it is grown (Flach 1997).

Sago palm is grown between latitude 10° north and 10° south in Southeast Asia and Pacific Island countries (Fig. 1.6).

Indonesia has the largest sago palm-growing areas (both wild and semi-cultivated stands) followed by Papua New Guinea, and limited semi-cultivated stands in Malaysia, Thailand, the Philippines, and Pacific Island countries (Table 1.1).

1.5.2 Specific Characteristics of Sago Palm

Sago palm has the following specific characteristics (Flach 1997):

Fig. 1.6 A map of sago palm-growing countries (Modified from google map)

- Grown in fresh water swamps and low-/wetland.
- Found in tropical areas with a warm temperature around 29–32 °C (minimum 15 °C).
- Found between latitude 10° north and 10° south, up to 700 m above sea level.
- Tolerant of mild saline water but usually borders on nipa palm swamps, which can withstand higher salinity water.
- Takes about 3.5 years before stem (trunk) formation starts.
- Takes 8–12 years to reach maturity stage (before flowering) suitable for harvesting.
- Sago grows about 10–12 m in height with a diameter of trunk at 35–60 cm.
- Fresh weight of trunk 1–2 mt, of which 10–25% of dried starch (about 100–300 kg of dried starch from one matured sago palm tree can be obtained).
- Average leaf production is 2 months. Leaves can be harvested when sago palm reaches about 4 years of age for making roofing materials.

Table 1.1 Distribution of sago stands by country

	Wild stands	(Semi-)cultivated stands
Papua New Guinea, total	1,000,000	20,000
Sepik Province	500,000	5000
Gulf Province	400,000	5000
Other provinces	100,000	10,000
Indonesia, total	1,250,000	148,000
Irian Jaya, total	1,200,000	14,000
Bintuni	300,000	2000
Lake Plain	400,000	–
Southern Irian	350,000	2000
Other districts	150,000	10,000
Moluccas	50,000	10,000
Sulawesi	— ^a	30,000
Kalimantan	–	20,000
Sumatra	–	30,000
Riau Islands	–	20,000
Mentawai Islands	–	10,000
Malaysia, total	–	45,000
Sabah	–	10,000
Sarawak	–	30,000
West Malaysia	–	5000
Thailand	–	3000
Philippines	–	3000
Other countries	–	5000
Total	2,250,000	224,000

Flach (1997)

^aNo wild stands

1.5.3 Sago Starch and Its Benefits

The trunk of sago palm has been used to obtain starch as a staple food for human consumption or fed to livestock. According to Flach (1997), at the semi-cultivated sago palm forests in Irian Jaya in Indonesia and Papua New Guinea, the local inhabitants harvest sago palm whenever the starch content per trunk is highest, just before the flowering starts. Their yields usually vary from 150 to 300 kg of dry starch per harvested trunk (Flach 1997).

Sago starch contains 27% amylose (the linear polymer) and 73% amylopectin, the branched polymer (Ito et al. 1979). However, Kawabata et al. (1984) found the amylose content of 21.7% in sago starch. Flach (1997) estimated that the difference of amylose content might occur according to the age, variety, or growing conditions of sago palm.

In some areas such as Southern Thailand, simple starch extraction methods are used at the farm household level, while a larger industrial-scale extraction is generally found in Indonesia and Malaysia. There are different starch extraction

methods in different countries. One of the common traditional methods of preparation of sago starch for human consumption is to pour hot water over the wet starch and stir it with a stick or a spoon. The resulting glue-like mass is eaten with some fish or other associated foods. It is also common to bake sago starch, occasionally mixed with other foods such as ground peanuts (Flach 1997). In Thailand, sago starch is occasionally used as a raw material for making breads, noodles, pasta, etc. (Klanalong 1999). The granular size of sago starch is about 30 μm on average, which is similar to that of potato and much larger than all other starches (Griffin 1977). Flach (1997) indicated that in the modern starch industry, starches can be modified to quite an extent. He also stated that sago starch would be competitive with all other starches and, for some purposes, it may even be preferred, provided there is a regular supply of cheap, clean, and noncorroded starch.

A recent study on the substitution of wheat flour with sago starch revealed that wheat flour can be substituted by sago starch up to a level of 40% in producing cookies that find good consumer acceptance in Southern Thailand. These findings highlighted the potential of sago starch to substitute and mix with wheat flour in other types of local confectionery and food products and eventually increase overall volume and availability of staple food worldwide; hence there might be a good potential for sago palm and its starch to contribute to household and global food security as a wheat flour substitution (Konuma et al. 2012).

In recent years, sago starch is given special attention as a potential source of ethanol production for biofuel due to global concern over climate change and a future energy crisis. It is estimated that whereas other food crops such as maize and cassava compete in the use of land resources for staple food production with that for biofuel production thereby increasing the risk of food insecurity, sago palm can be grown on marginal land or on land where other food crops are unable to grow economically.

1.5.4 Sago Palm's Contribution to Household Economy and Income Generation

Sago starch is utilized in some of southern rural villages in Thailand as a raw material to produce food for income generation at the village level. The traditional sweets, cookies, and snacks produced from sago starch are an important extra income of farm families (Konuma 2008).

Sago leaves are widely used to make mats for roofing or partitioning (Flach 1997). Sago roofing mats are strong and last longer than those made from other palms and are an important source of income of sago growers. The useful life of sago leaf roofing mats is about 6–10 years, which is more durable than those made from other palms. Sago rachis is used for producing woven mats and racks for holding shrimps, fish, or vegetables during sun-drying in Thailand. Sago latex, collected from fresh rachis, is clear and very sticky and is used as paper adhesive in Thailand (Konuma 2008).

Fig. 1.7 Sago worm farming at Fukkeri Village, Nakhon Si Thammarat Province in Thailand (Photo taken on 23 February 2007 by Hiroyuki Konuma)

The ground pith of sago palm is sometimes used as an animal feed, especially for pigs. When dried, it is also used for horses and chickens (Flach 1997). The lower part of trunk is also used for sago worm farming in Southern Thailand which generates additional income for farmers (Klanalong 1999). Figure 1.7 shows an example of worm farming.

1.5.5 Sago Palm and Its Social and Environmental Contribution

In countries like Indonesia, Malaysia, and Thailand, rapid expansion of the oil palm industry and rubber plantations reflects increased world demands and the price hike is another factor which affected the traditional farming systems. As a result, wetlands and peat swamps including sago palm forests have been rapidly disappearing and replaced by industrial crop plantations. The overall situation negatively affected the environment and sustainable ecosystem as well as the traditional social values, culture, and livelihoods of people living in rural communities. A study indicated that sago palm forest was an important local resource of the rural communities in Southern Thailand (Konuma 2008). The villagers have harmonized their traditional lifestyle and community spirit with the sago palm forest for their farming system, economy, and culture. Sago palm trees, with the benefit of their large green leaves existing year-round, would naturally contribute to absorbing carbon dioxide and

hence contribute to reducing greenhouse gas emissions. Through the review of various research reports, it was found that sago palm played an important role as a symbol for the protection of traditional landscape and ecosystems, biodiversity, and sociocultural heritage in southern part of Thailand.

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