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Social and Economic Impact of Fall Army Worm (FAW) in the Pacific Island Countries

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Social and Economic Impact of Fall Army Worm in Papua New Guinea

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Acronyms

ASF	African Swine Fever
CIMMYT	The International Maize and Wheat Improvement Centre
DAF	The Queensland Department of Agriculture and Fisheries
DFAT	Australian Government Department of Foreign Affairs and Trade
FAO	Food and Agriculture Organisation
FAW	Fall Army Worm
GRDC	Grains Research and Development Corporation
HPR	Host Plant Resistance
HS	Highly susceptible to FAW attack
IITA	International Institute of Tropical Agriculture
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
NS	NS susceptible to FAW attack
PICs	Pacific Island Countries
PNG	Papua New Guinea
S	Susceptible to FAW attack
SRA	Sugar Research Australia

Section 1. Background

Fall Army Worm (FAW) (*Spodoptera frugiperda*) has been a pest of crops in Central and South America for centuries where it mainly affects maize. Beginning in 2016, FAW spread rapidly and has now been reported almost everywhere in the tropical latitudes. In late 2019 FAW was detected in the Torres Straight Islands, spreading to North Queensland during the first months of 2020 and migrating rapidly southwards thereafter. In PNG the pest was detected by a NAQIA survey team in maize at Daru in Western Province in February 2020, and has been confirmed as being the same strain as FAW found in the Torres Straight Islands and Northern Australia. Surveillance work in PNG is continuing and there are initial reports that the pest has been found along the southern coastal provinces as well as Morobe, Madang and some highlands provinces.

The rapid spread of FAW through Africa and Asia, the damage caused to crops, and the near impossibility of eradicating the pest has raised major concerns about its possible impact in the Pacific Island Countries (PICs). A PHAMA Plus study[1] of the potential social and economic impact of FAW in PNG in March-April 2020 estimated that the social and economic impact of the pest in PNG could range from minor and limited in scope to catastrophic. However the study was unable to reach definitive conclusions about the likelihood of the different eventualities due to major shortcomings in data on the agricultural sector; as well as unknowns about the speed and extent of FAW's geographic spread, the range of host species, and the magnitude of crop yield reductions. The same uncertainties have affected the current study.

Following the PNG study, DFAT requested PHAMA Plus to prepare preliminary estimates of how FAW might affect the other five PHAMA Plus countries, Fiji, Samoa, Solomon Islands, Tonga and Vanuatu. This preliminary report provides an overview of cropping systems in the five countries including both commercial and smallholder subsistence crops, and their level of susceptibility to FAW attack. This is followed by some impact assessments based on FAW outbreak scenarios of varying severity ranging from a small range of highly susceptible crops, to affecting many susceptible crops and farming systems.

The impact estimates are regarded as indicative due to significant uncertainties about the range of crops likely to be affected by FAW, the area on which these crops are currently grown, and their social and economic value. The analysis is reliant on agricultural census reports from each of the five study countries which provide estimates of the area of FAW-susceptible crops in each country and in some cases estimates of crop yields and revenues generated. However, the content of the census reports differs between countries making between-country comparisons difficult. Moreover, the census dates span a full decade, none being very recent: Vanuatu 2007 and 2016 mini-census; Fiji 2009; Samoa and Tonga 2015; and Solomon Islands 2017.

The analysis also makes reference to estimates of crop areas and yields in the Food and Agriculture Organisation (FAO) statistical database[2] most of which are derived from national statistical records. The national census records are summarised in Annex 4.

Considerable desk based, laboratory and field-based research on FAW has been on-going in Australia and internationally since the PHAMA Plus PNG study was finalised[3]. A key focus of this work is to better

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[1] PHAMA Plus (April 2020). Social and Economic Impact of Fall Army Worm in Papua New Guinea – Preliminary Estimates.

[2] www.fao.org/faostat/en/#home

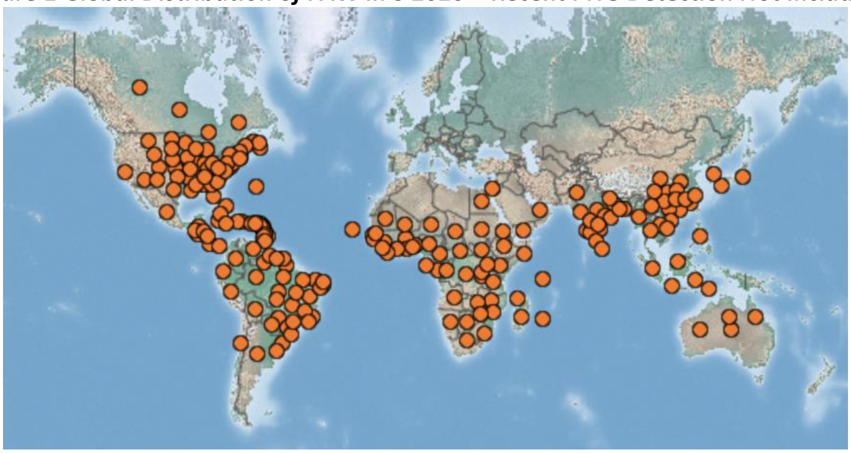
[3] https://groundcover.grdc.com.au/weeds-pests-diseases/biosecurity/researchers-work-to-better-understand-faw-and-identify-rd-and-e-further-priorities ; https://groundcover.grdc.com.au/weeds-pests-diseases/biosecurity/faws-genetics-and-insecticide-sensitivities-explored-to-develop-pest-management-plans ; https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/priority-pest-disease/fall-armyworm

understanding the biology of FAW, how it may behave and impact Australian (and to a limited extent PNG and the Pacific) agriculture and what are sustainable management approaches. This will be useful in guiding management approaches in coming years but is also highlighting the on-going risk of transboundary (or migratory) pests, uncertainty over how this particular pest may impact the region, differentiating it from similar pests that are already present, and what changes to existing production practices are needed.

Section 2. Fall Army Worm

FAW[4] is the larva of a moth that feeds in large numbers on the leaves, stems and reproductive parts of crops, causing major damage and yield losses. Although the pest is known to affect some 350 crop species, the great majority of damage reports apply to cereal crops such as maize, rice, sorghum, sugarcane and wheat (see list of susceptible plant species in Annex 2). FAW is native to the Americas and was first reported in Africa in 2016 where it has caused significant damage to maize, which is the staple food over much of the continent. In 2018, FAW was reported in India and has since spread to Bangladesh, Thailand, Myanmar, China and Sri Lanka. The current distribution of FAW is shown in Figure 1 below (PNG's recent outbreak is not yet shown). The ideal climatic conditions for FAW are present in many parts of Africa and Asia, and the abundance of host plants enables the pest to produce multiple generations in a single season, causing widespread crop damage. The adult moths can fly long distances and lay large numbers of eggs, so FAW is able to spread rapidly. There have been no successful attempts to eradicate the pest or even prevent it's spread, but a number of control measures have been developed.

Figure 1 Global Distribution of FAW in S 2020 – Recent PNG Detection Not Included



Source: Centre for Agriculture and Bioscience International https://www.cabi.org/isc/fallarmyworm

FAW is a tropical species adapted to the warmer parts of the World. The optimum temperature for larval development is reported to be 28°C, but it is lower for other phases of the life cycle including egg laying and pupation. In the tropics, breeding can be continuous with four to six generations per year, but in cooler regions only one or two generations develop. At lower temperatures, activity and development cease, and when frosts occur all stages are usually killed. However, this does not prevent re-infestation when temperatures rise again.

There are two sub-types of FAW which appear identical but vary in their host plant preference with one group preferring rice (R Strain) and various pasture grasses, and the other maize, cotton and sorghum (M Strain). There are also hybrids between the two strains.

[4] Key sources of information about FAW are listed in Annex 1.

Reports on the yield losses attributable to FAW mainly concern cereal crops, particularly maize which is a key food crop in the original focal area of the pest in Central and South America and USA, and in the recently affected parts of Africa. In the Americas researchers and farmers have learned how to manage FAW using a range of chemical and other methods and yield losses are generally small. However, yield losses are severe when FAW invades areas previously free of the pest. In these situations, estimated maize yield losses vary between 25% and 50%, with some reports as low as 12% or as high as 70% depending on the percentage of plants infested and the stage of crop development. Yield losses in sugarcane are reported to be in the 15% to 20% range. There is limited information available on yield losses in other cereals and virtually no information on non-cereal crops.

It is near impossible to eradicate FAW or limit its spread due to the dispersion capacity of the adult moths (they can fly hundreds of kilometres, more if wind assisted). The Queensland Department of Agriculture and Fisheries (DAF) stated that eradication was not a realistic prospect soon after FAW was first detected in North Queensland. However, it is possible to limit damage to crops on affected farms or villages by control measures. Such measures are based on research and field experience of countries such as USA and Brazil that have dealt with FAW for decades. Because pesticides have been used to control FAW for many years, pesticide resistance is already apparent in many FAW populations. The International Maize and Wheat Improvement Centre (CIMMYT) has produced a guide for management of the pest in Africa, based mainly on experience from the Americas, using integrated pest management (IPM) principles (see Box 1).

Box 1 Objectives and Principles of IPM

- Prevent or avoid pest infestations using a combination of environmentally friendly approaches at the field, farm, and landscape scale, such as cultural control, landscape management, host plant resistance, and biological control.
- Implement routine scouting to identify and respond to potentially damaging pest infestations when they occur.
- In the event of a pest infestation, suppress the pests using a combination of biological, physical, and if necessary, chemical approaches – leveraging interactions between complementary approaches in order to maximise control of the pest while minimising potential risks to human and animal health, the environment, and natural enemies of the pest.
- Minimise the amount and toxicity of chemical pesticides applied to achieve control of the pest.
- Provide scientifically validated, evidence-based choices to farmers on how to safely and effectively mitigate the potential damage of their crop(s) from a specific pest or combination of pests.
- Maximise the contributions by all stakeholders, and incorporate new, practical findings as they become available for continuous improvement.
- Manage insect resistance to pesticides by minimising their use.

Source: Prasanna B.M., Huesing J.E., Eddy R., and Peschke V.M. (eds))2018) Fall Armyworm in Africa: A Guide for Integrated Pest Management, First Edition. Mexico, CDMX: CIMMYT.

The CIMMYT IPM guidelines target African maize farmers and include five elements:

- Monitoring, surveillance and scouting
- Pesticide use and pesticide hazard management
- Host plant resistance

- Biological control and biorational pesticides[5]
- Low cost agronomic practices and landscape management approaches

Further details on the CIMMYT guidelines are provided in Annex 3. The guidelines are regarded as preliminary since they are based mainly on research and field experience from the Americas, that has not yet been validated in Africa. FAO has also produced a series of guidance notes[6] on FAW management (see also in Annex 3) in maize crops that are based on IPM principles and the experience of the Americas. FAO notes that many farmers in Africa are beginning to adopt these traditional management methods, with adaptations to local conditions that vary from place to place.

Section 3. FAW in the PICs

3.1 Current Situation

FAW was detected in PNG by the National Agriculture and Quarantine Inspection Authority (NAQIA) in maize crops at Daru in Western Province. Damage includes defoliation and burrowing into the stem nodes. This is a lowland location is close to the Torres Straight Islands where the pest was detected a few months earlier. The experience from rapid spread of FAW in Asia suggests a high risk that the pest will soon appear in other parts of PNG although the speed and extent of the spread is impossible to predict in light of PNG's unique geographic and agro-ecological conditions. The lowlands and Islands are likely to be more vulnerable than the highlands due to the pest's preference for warm, wet conditions, and because its life cycle is longer under cooler conditions.

FAW populations in Australia and PNG are hybrids between the R and M strains, which creates uncertainties about their host plant preferences and insecticide resistance profiles. However, observations suggest[7] that the hybrid population in Australia, presumably also in PNG, prefers maize/sweet corn, and can cause devastating yield losses if not appropriately managed. So far there are no reports of FAW attacking sugarcane in Australia even in the proximity of maize that has been infested.

The risk of spread from Australia and/or PNG to other PICs is obviously greatest in the proximate Melanesian countries of Solomon Islands, and Vanuatu which also have similar climatic and agro-ecological conditions to the PNG lowlands; less so for Fiji, Samoa and Tonga due to their relative isolation, and in the case of Tonga, cooler winter conditions.

3.2 Possible Impacts

The impact of FAW in the PICs is related to the prevalence of cereal crops (the most vulnerable species) in farming systems, the extent to which it may also feed on other plants, and the ability of existing controls (e.g. natural enemies; deliberate or other production practices that control other pests). Cereal production represents a small part of the agricultural sector in all five of the study countries, apart from sugar in Fiji, and small areas of rice in Fiji, Vanuatu and Solomon Islands. The other countries grow small areas of maize and sweetcorn, but in no case do these constitute an important cash or food crops. All PICs rely heavily on imported cereals and cereal products including rice and

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[5] Defined by CIMMYT as pest control products that are efficacious against target pests but are safe to natural enemies and broadly to the environment. They often include products that are derived from natural sources such as botanicals, biopesticides, and others.

[6] FAO Guidance Note 4. How to Manage Fall Armyworm: A Quick Guide for Smallholders. www.fao.org/3/CA0435EN/ca0435en.pdf

[7] Personal Communication (September 2020), Reynolds O, Team Leader – Research, cesar and Associate Research Professor, Charles Sturt University, Australia

wheat/flour for human food and maize/sorghum for livestock feeds. Sugarcane has not so far been affected in the FAW infested parts of eastern Australia, which is cause for optimism about the vulnerability of Fiji's sugar industry. Rice production in Fiji, Vanuatu and Solomon Islands supplies only a small portion of those country's rice requirements and has always struggled to be economically viable.

Whilst FAW can cause serious crop losses for individual growers, if the damage is confined mainly to cereals the impact of the pest in the PICs is unlikely to be large due the relatively minor role of cereals in the agricultural sectors of these countries, with sugarcane in Fiji being a notable exception. Of course, the situation would be much more serious if the pest behaves differently in the PICs and attacks non-cereal crops in a major way (as in Scenario 2 below), but experience from Australia/PNG and other parts of the world, both newly infested and endemic areas, suggests that cereals will be the pest's main target.

In considering possible impacts, it should also be recognised that insect pests are usually the most devastating when they first invade previously un-affected areas. The impacts usually moderate over time as the agro-ecosystem re-balances, natural enemies multiply, hosts develop resistance and farmers learn how to manage the pest. For example, Bourke and Sar (2020)[8] consider it likely that the impact of FAW in PNG may be severe initially, but will moderate over time, as follows:

> "Fall armyworm has the potential to cause significant damage to a number of important food and commercial crops in PNG, particularly maize (corn), but also sugarcane, rice and other food crops. Based on experience in Africa and now Australia, it is likely that the pest will spread quickly throughout PNG and possibly nearby Melanesian nations. It is possible that initially the pest will cause a lot of damage as its natural enemies are absent in PNG. However, over a time period of some years, there may be less damage as the natural enemies of the pest arrive in PNG. There is much that is unknown about how much damage this pest will do to crops in PNG and how this will change over time."

3.3 Response Options

New insect pest incursions can sometimes be eradicated by quick action including insecticide application, destruction of affected crops, pheromone trapping etc. This possibility exists for pests that can be detected very quickly, have low dispersal capacity or where human activity (such as movement of infested fruit, seeds etc.) plays a role. However, human activity plays no role in the spread of FAW, and efforts to control its spread by limiting the movement of people or agricultural produce will have no beneficial effect. The adult moths have great ability to disperse over long distances. Consequently, no country has been able to eradicate FAW, or even contain its spread. Learning to live with the pest is the only option.

With national eradication or containment most unlikely, FAW has to be managed at local level by individual farmers and communities. There are four main response options.

- Do nothing and tolerate the losses. This is likely to see yield losses in affected crops of 25%-50% for maize, sorghum and rice and 15%-20% in sugarcane. Under this option there could also be yield losses in a number of other crops – see list of potentially affected crops in Annex 2 – but the number of species affected and the extent of losses is unknown.
- Remove susceptible crops from the farming system.
- Apply insecticides to control outbreaks and limit damage. This option raises issues with cost, availability of the right insecticides, safety, insecticide resistance and technical aspects such

[8] Bourke R.M. and Sar S (2020) Potential Impact of Fall Armyworm in Papua New Guinea. Un-published discussion note.

as timing of application. Insecticides alone are only a short-term response at best and may in fact worsen the situation longer term.

- Develop and apply an IPM regime along the lines of FAO and CIMMYT including biological control, plant breeding, use of resistant/tolerant varieties, as well as carefully measured use of insecticides, etc.

Section 4. Approach and Methodology

Assessment of the baseline (without FAW) situation in the five study countries involves estimates of the extent of FAW susceptible crops and their importance in generating income and food for rural communities. Annex 4 summarises the best-available information on crop production in each country based on their most recent agricultural survey or census.

Each of the crops produced in the PICs is classified as either: (i) highly susceptible (HS) to FAW attack – basically the grassy crops (sugarcane, maize and rice); (ii) susceptible (S) – the other 37 host species listed in Annex 2; or non-susceptible (NS) - all other species. There are some uncertainties about these categorisations because some of the traditional/indigenous crops grown in the PICs have not been exposed to FAW in other parts of the world. Kava is such an example. Kava (*Piper Methysticum*) is a member of the *Piper* genus along with pepper (*Piper nigrum*) which is listed as one of the crops in Annex 2.

Combining the available data on crop production in each country with the classification of crops according to their level of susceptibility provides some indications of how FAW might affect different countries in terms of the area of crops and/or numbers of households affected under different outbreak scenarios (see Section 5 following).

This methodology has a number of unavoidable limitations, related to the lack of up-to-date information on crop areas and yields, and unknowns about the range of crops and farming systems likely to be affected by FAW and the extent of the damage. Moreover, the epidemiological scenarios and crop loss estimates are mainly based on reports from the Americas and Africa because there has not yet been an assessment on how FAW will behave in the PICs, the crops it will affect, or the damage it is likely to cause.

Section 5. Impact Scenarios

5.1 Overview

The analysis of possible FAW impacts in the five study countries considers two main impact scenarios:

- **Scenario 1 - Cereals Only:** Impacts would be limited to the highly susceptible species including sugarcane, rice and small areas of maize and sweetcorn, plus possibly some pasture grasses. Experience in Australia suggests that with the hybrid strain of FAW currently present, the likelihood of significant impacts on sugarcane production is low. The overall social and economic importance of rice and maize is generally low (although important to some individuals).

- **Scenario 2 – Cereals Plus Non-Cereal Crops:** This scenario covers a range of possibilities from isolated outbreaks in a small number of the less important non-cereal crops, to widespread attack on a range of important crops such as sweet potato, banana, papaya, vegetables etc. which would have serious economic and food security consequences.

These impact scenarios have varying consequences across the five study countries as follows.

5.2 Fiji

The latest crop statistics for Fiji from the 2009 Agricultural Census[9] are shown in Annex 4 and summarised in Table 1 below. Fiji has crop land estimated to cover 127,000 hectares of which almost half is sugarcane which is classified as highly susceptible to FAW. However, according to FAO statistics the area of sugarcane has declined since 2009 and is now around 35,000 hectares. Other highly susceptible crops in 2009 included 3,624 ha of rice (also likely to have declined since then) and 536 hectares of maize (probably increased). This means that around 40% of the current crop area in Fiji is categorised as highly susceptible, much larger than in any other PIC due to the importance of sugarcane, and to a lesser extent rice.

Table 1 Summary of Crop Statistics for Fiji

Crop	hectares '0000 a/				Percent			
Category	HS	S	NS	Total	HS	S	NS	Total
Temporary	4.2	5.4	32.6	42.2	3.3	4.3	25.7	33.3
Permanent		2.2	25.0	27.2		1.7	19.8	21.5
Sugarcane	57.2			57.2	45.2			45.2
Total	**61.3**	**7.6**	**57.6**	**126.6**	**48.5**	**6.0**	**45.5**	**100.0**

a/ HS = highly susceptible: S = susceptible: NS = not susceptible

Around six percent of the crop area in Fiji is in the susceptible category. This includes some of the important food staples such as bananas, plantains and sweet potato; as well as a range of commercial fruit and vegetable crops including ginger, watermelon, papaya, tomatoes, cabbages, eggplant, okra, beans, pumpkins, capsicum and others. Some of these, notably ginger, papaya, okra and eggplant are significant export commodities.

5.3 Samoa

The crop statistics from the Samoa 2015 agricultural survey are shown in Annex 4 and summarised in Table 2 below. Samoa has around 58,000 ha under crop, about two thirds of which is permanent crops, principally coconuts, with smaller areas of bananas, cocoa and breadfruit. Apart from a very small area of sweet corn, none of the crops are regarded as highly susceptible to FAW. Around 13% of the total crop area is classified as susceptible to FAW including most importantly bananas, as well as a range of other fruits and vegetables including pumpkins, tomatoes, eggplant, cucumbers, mangoes, papaya and citrus fruits. The major food crops, taro and ta'amu (giant taro) are categorised as non-susceptible.

Table 2 Summary of Crop Statistics for Samoa

Crop	hectares '0000 a/ b/				Percent			
Category	HS	S	NS	Total	HS	S	NS	Total
Temporary	0.0	3.3	15.5	18.8	0.0	5.6	26.6	32.2
Permanent	0.0	4.3	35.2	39.5	0.0	7.4	60.4	67.8
Total	**0.0**	**7.6**	**50.7**	**58.3**	**0.0**	**13.0**	**87.0**	**100.0**

a/ HS = highly susceptible: S = susceptible: NS = not susceptible
b/ hectarage of minor crops not reported

5.4 Solomon Islands

The Solomon Islands agricultural survey of 2017, reported in Annex 4, estimated that there was a total of 181,000 hectares planted to crops in four categories: major cash crops (coconuts and cocoa); major vegetables and root crops (mainly the staples of cassava, sweet potato and taro); major fruits (citrus, banana, papaya and breadfruit); and other crops, comprising a diverse range of indigenous and

[9] A new agricultural census is currently in process, although disrupted by the COVID-19 situation.

imported fruits and vegetables. Table 3 below shows that none of the major cash crops are susceptible to FAW. However, sweet potato which comprises about 40% of the area planted to staple food crops, is classified as susceptible. Most of the major fruit crops are also considered susceptible including citrus, banana and papaya. In the other crops category, a number of important vegetable crops are susceptible to FAW including tomatoes, cucumbers, pumpkins, peanuts, cabbages and many others. However, these only amount to around four percent of the total cropped area.

Table 3 Summary of Crop Statistics for Solomon Islands

Crop	hectares '0000 a/ b/				Percent			
Category	HS	S	NS	Total	HS	S	NS	Total
Major Cash Crops			47.1	47.1	0.0	0.0	26.0	26.0
Major Veg/Root Crops		32.0	36.7	68.7	0.0	17.7	20.2	37.9
Major Fruits		19.7	4.1	23.9	0.0	10.9	2.3	13.2
Other		6.9	34.6	41.5	0.0	3.8	19.1	22.9
Total	**0.0**	**58.6**	**122.5**	**181.1**	**0.0**	**32.4**	**67.6**	**100.0**

a/ HS = highly susceptible: S = susceptible: NS = not susceptible

5.5 Tonga

The 2015 Tonga agricultural census reported in Annex 4 and summarised in Table 2 below reveals a different cropping pattern to the other study countries. Non-susceptible coconuts dominate the perennial crops sub-sector. Root crops account for 56% of the total cropped area (15,949 hectares), supplying the bulk of the domestically-produced staple foods as well as a substantial and growing export trade. The main root crops are cassava, yams, taro (various types), giant taro and sweet potato, with only the last of these being FAW susceptible. However sweet potato is one of the least important of the root crops, with over 90% of root crop plantings being of non-susceptible species. Amongst the other crops only 15 hectares of corn are classified as highly susceptible. However, a number of other crops are classified as susceptible including plantains and bananas, a number of common fruits and vegetables and the cucurbits, squash, pumpkins and watermelons - which are important exports.

Table 4 Summary of Crop Statistics for Tonga

Crop	hectares '0000 a/ b/				Percent			
Category	HS	S	NS	Total	HS	S	NS	Total
Coconuts			4.8	4.8	0.0	0.0	30.1	30.1
Root crops		0.8	8.2	9.0	0.0	4.8	51.6	56.4
Other crops	0.01	0.8	1.3	2.1	0.1	5.0	8.4	13.5
Total	**0.01**	**1.6**	**14.4**	**15.9**	**0.1**	**9.8**	**90.1**	**100.0**

a/ HS = highly susceptible: S = susceptible: NS = not susceptible

5.6 Vanuatu

The statistical base for Vanuatu is less informative that the other study countries because it does not report the areas of crops grown, only the number plants grown or the number of households involved. In addition, the information is dated with the most recent agricultural census conducted in 2007, with some information available from the general mini-census conducted in 2016 in the aftermath of Cyclone Pam. However, the mini-census only reports the number of households growing specific crops not the areas grown. This means that it is only possible to obtain a general indication of the relative importance of various crops within Vanuatu, and that comparisons with other countries are not possible. The available data are shown in Annex 4 and summarised in Table 5 below. It shows that around 11% of Vanuatu households grow highly susceptible crops, principally maize, with a few growing rice. Almost half of the households grow susceptible crops of which bananas, papaya, sweet potato and peanuts re the most common, all grown mainly as subsistence food crops.

Table 5 Summary of Crop Statistics for Vanuatu

	HH'000	Crops
Total No of Households	267	
No of HH growing highly susceptible crops	30	Mainly maize and some rice
No of HH growing susceptible crops	129	Banana, papaya, sweet potato, peanuts, limes, pepper
No of HH growing non-susceptible crops	231	

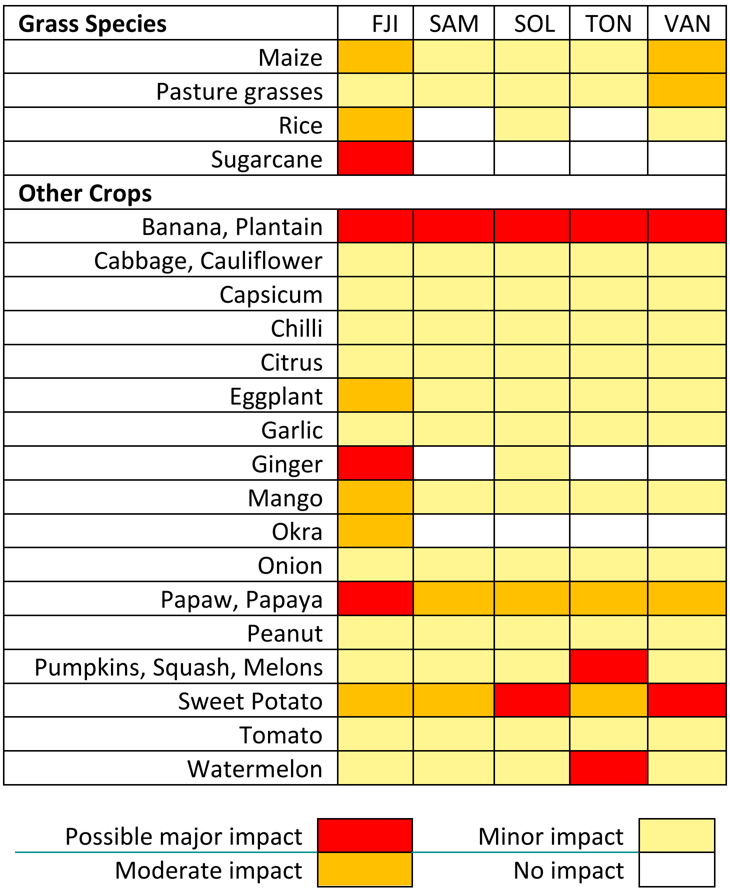
Source: 2016 Mini-Census

Section 6. Conclusions

6.1 General Conclusions

According to the scenarios outlined in Section 5, the crops most likely to be affected in each country and the possible impact level based on the economic importance of each crop, are summarised in Figure 2 below.

Figure 2 Crops Most Likely Affected and Possible Socio-Economic Impact



However, it is difficult to reach firm conclusions about the likelihood of the different eventualities due to major shortcomings in data on the agricultural sectors of the five study countries; as well as unknowns about the speed and extent of FAW's geographic spread, the range of host species, and the magnitude of crop yield reductions.

The impact scenarios described in Section 5 depict a range of possible outcomes, mostly minor and limited in scope on a national scale, although damaging to the affected households. However, there are two possible more serious eventualities.

- Under Scenario 1, if FAW was to reach Fiji and attack sugarcane crops, this would be a serious blow to an important but already struggling agro-industry which accounts for around half of agricultural land use in the country, given the expectation of a 15%-20% reduction in yields. However, the hybrid strain of FAW that has established in Australia and PNG has not yet been detected in sugarcane crops, despite affecting maize growing in sugarcane areas. The likelihood of this outcome is therefore considered low in the short-medium term, but could be significant if there are further incursions of FAW strains with a preference for sugarcane.

- Under Scenario 2, across all five study countries there is a risk that FAW could become a pest of one or more of the non-grass crops that are classified as susceptible to FAW and where FAW has been found to cause damage in other parts of the world. As show in in Annex 2 there is considerable taxonomic diversity in the range of susceptible species (37 species, 29 genera and 23 families), so damage levels could vary greatly across agro-ecological zones and farming systems. Whilst widespread attack across many species, countries and farming systems is unlikely, localised damage to specific crops could have serious consequences for affected households in terms of food security and income generation as follows:

    - Bananas, plantains and various fruits and vegetables are vital to the food security of both rural and urban communities in all PICs. Sweet potato is also grown in all countries and is an important food staple in several including Solomon Islands and Vanuatu. FAW attack on some or all of these crops would threaten the already fragile food and nutrition status of the affected countries.

    - In all of the five study countries, fresh produce markets offer a range of fruits, vegetables and root crops which provide nutritious food to urban communities and generate cash income for many rural households. About half of the 37 species considered susceptible to FAW are commonly found in fresh produce markets. There is sufficient resilience in food and livelihood systems to adapt to FAW attack on a small number of the susceptible species – people will grow and eat different things. But there is a risk of significant impacts on rural incomes and urban food supplies in the event of FAW attack on a broader front, exacerbated in the short-term by COVID-19 restrictions affecting fresh produce marketing.

    - Export industries could be affected in some cases, especially in Fiji (ginger, eggplant, okra etc.) and Tonga (watermelon, squash, pumpkins). Although FAW normally spreads by natural dispersion, rather than via movement of agricultural produce, if the pest is detected in any of the PICs, importing countries would likely impose additional biosecurity measures for all susceptible products.

Another possibility which cannot be ruled out is that FAW could attack kava which is in the same family and genus as pepper which is listed as a susceptible species. This could have serious consequences in the countries where kava is a major cash crop including Vanuatu, Fiji and Tonga.

It is also difficult to assess the between-country differences in vulnerability to FAW. Agro-biodiversity is a key defence to pest and disease challenges, as well as other stressors such as climate change. In the PICs agro-biodiversity declines from the West to the East of the region[10], corresponding to the recency and distance of human migration. This applies to both the number of crop species and genetic variation within them. The devastating impact of Taro Leaf Blight in Samoa is a powerful example the vulnerability of a narrow genetic base. In this light, it is likely that agro-ecosystems in the Melanesian countries would prove more resilient to FAW attack than in the Polynesian countries to the east (and Micronesia to the north). However, the probability of FAW incursion works in the opposite direction

[10] Taylor M (2017). Adaptation for Resilient Agriculture in the Pacific. Working Paper No 3: Management of Plant Genetic Resources. International Fund for Agricultural Development.

with Solomon Islands and Vanuatu being highly vulnerable in because of their proximity to Australia and PNG, Fiji less so, and Samoa and Tonga least vulnerable.

Another way of looking at relative vulnerabilities is via the mix of crops grown in each country and the number of these which are considered susceptible or highly susceptible to FAW. Table 6 below shows that there are no marked differences between the five countries in this regard, apart from Solomon Islands where a significant number of traditional/indigenous are crops grown, not found elsewhere and not listed as susceptible to FAW – although some of these could be susceptible if the pest arrives.

Table 6 Number of Crops According to Level of Susceptibility to FAW

Country	Number of Crops a/				Percent
	HS	S	NS	Total	HS or S
Fiji	2	23	25	50	50
Samoa	1	19	25	45	44
Solomon Islands	-	22	47	69	32
Tonga	1	21	25	46	48
Vanuatu	3	26	31	60	48
Average	1.4	22	31	54	43

HS = highly susceptible to FAW: S = susceptible: NS = not susceptible.
a/ Number of crops recorded in agricultural censuses.

6.2 Response Strategies

Estimating the potential economic impact of FAW is a near-impossible and not very useful exercise in formulating response strategies, given the very diverse range of possible outcomes, and the many uncertainties surrounding the various scenarios. For most plant pests and diseases, preventing spread through appropriate biosecurity measures is the first and best option.

However, in the case of FAW, even considering the more serious eventualities, efforts to prevent the incursion of the pest are unlikely to be effective. There are no biosecurity measures that can be taken to reduce the risk of FAW incursion since movement of agricultural produce is not implicated in its spread. However, to have any chance of eradicating the pest, early detection is essential, and in this regard, it would be valuable to train agricultural extension workers to recognise and report the pest if it appears; and to prepare contingency plans for rapid suppression of any outbreaks that may occur.

Should such suppression efforts fail – a likely outcome based on the experience of other countries - and the pest become established, the strategy would need to shift to adaptive measures including the following:

- A surveillance programme covering the different agro-ecosystems to assess the distribution of FAW and to identify potential hot spots where its impact may be greatest.
- Studies to identify the crop species and varieties affected and the extent of damage caused.
- Identification of short-term response measures to limit damage, possibly including targeted use of pesticides.
- A research programme, likely spanning several years, to develop pest management regimes based on IPM principles.
- Awareness-raising and training for extension workers and rural communities in how to manage FAW.

This impact assessment exercise, and recent similar assessments of the economic impact of African Swine Fever (ASF) have been seriously hampered by the very limited agricultural sector statistics in the PICs. Several countries have not conducted agricultural censuses for more than a decade, or they have been conducted but the data is not yet publicly available (e.g. Fiji) and FAO statistics on crop production are un-validated estimates that are questioned by many, but sometimes have to be used in the absence of anything better. These data limitations make planning for the agricultural sector a very inexact process, with ramifications far beyond the studies on FAW and ASF. Much more needs to be done in this regard to provide a credible basis for future policy and planning work.

Annex 1: Sources of Information on Fall Armyworm

ABC News CSIRO Researcher Issues Dire Warning for Australian Agricultural Industry after Fall Armyworm Found on Mainland	https://www.abc.net.au/news/2020-02-18/researcher-warning-as-fall-armyworm-detected-australian-mainland/11975908
Business Queensland: Fall Armyworm Advice and Management	https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/fall-armyworm
Centre for Agriculture and Bioscience International (CABI). Invasive Species Compendium: Fall Armyworm Portal	https://www.cabi.org/isc/fallarmyworm http://www.fao.org/fall-armyworm/en/
International Maize and Wheat Improvement Centre (CIMMYT). Fall Armyworm in Africa: A Guide for Integrated Pest Management	https://repository.cimmyt.org/handle/10883/19204
Food and Agriculture Organisation (FAO). FAO Guidance Note 4. How to Manage Fall Armyworm: A Quick Guide for Smallholders.	www.fao.org/3/CA0435EN/ca0435en.pdf
Grains Research and Development Corporation (GRDC). Prevention and Preparedness for Fall Armyworm	https://grdc.com.au/research/applying-and-reporting/current-procurement/open-tenders/prevention-and-preparedness-for-fall-armyworm-spodoptera-frugiperda
Hort Innovation (Australia). Fall Armyworm Update and Alert	https://www.horticulture.com.au/hort-innovation/news-events/fall-armyworm-update-and-alert/
International Institute of Tropical Agriculture (IITA). First Report on Outbreaks of Fall Armyworm on the African Continent.	http://bulletin.iita.org/index.php/2016/06/18/first-report-of-outbreaks-of-the-fall-armyworm-on-the-african-continent/
International Plant Protection Convention (IPPC) Fall Armyworm – an Emerging Food Security Global Threat	https://www.ippc.int/en/news/fall-armyworm-an-emerging-food-security-global-threat/
Pacific Pests and Pathogens. Fall Armyworm Factsheet	https://apps.lucidcentral.org/ppp/text/web_full/entities/fall_armyworm_401.htm
Queensland Department of Agriculture and Fisheries (DAF). Potential Impact of Fall Armyworm on Sugarcane	https://sugarresearch.com.au/wp-content/uploads/2020/03/sugarcane-faw-fact-sheet-updated.pdf
Sugar Research Australia (SRA). Fall Armyworm	https://sugarresearch.com.au/pest/fall-armyworm/ https://sugarresearch.com.au/wp-content/uploads/2020/03/Fall-Army-Factsheet_2020_F.02-310320.pdf
Wikipedia: Fall Armyworm	https://en.wikipedia.org/wiki/Fall_armyworm

Annex 2: Plant Species Susceptible to FAW Attack

Source: CABI Invasive Species Compendium: Fall Armyworm Portal
https://www.cabi.org/isc/fallarmyworm

Datasheet 29810

FAW is a polyphagous pest which shows a definite preference for the Poaceae (grass) family. It is most commonly recorded from wild and cultivated grasses; from maize, rice, sorghum and sugarcane. However, researchers have reported 353 host plant species based on a thorough literature review, and additional surveys in Brazil, from 76 plant families, principally Poaceae (106), Asteraceae (31) and Fabaceae (31).

The list of crops grown in the PICs that are likely to be severely affected are three crops in the Poaceae family: rice, sugarcane and maize/sweetcorn; plus a range of pasture grasses. Crops possibly affected but not generally considered major targets of FAW include some of the major cash and food crops, notably bananas, sweet potato and a range of fruits and vegetables.

Species	Common Name	Family
Main FAW Susceptible Grass Species in PICs		
Oryza sativa	Rice	Poaceae
Saccharum officinarum	Sugarcane	Poaceae
Zea mays	Maize, Sweetcorn	Poaceae
Various	Pasture Grasses	Poaceae
Other PIC Crops Possibly Affected		
Abelmoschus esculentus	Okra	Malvaceae
Allium cepa	Onion	Liliaceae
Allium sativum	Garlic	Liliaceae
Arachis hypogaea	Peanut	Fabaceae
Asparagus officinalis	Asparagus	Asparagaceae
Beta vulgaris	Beetroot	Chenopodiaceae
Brassica oleracea	Cabbage, Cauliflower	Brassicaceae
Cajanus cajan	Pigeon pea	Fabaceae
Capsicum annuum	Capsicum	Solanaceae
Capsicum frutescens	Chilli	Solanaceae
Carica papaya	Papaw, Papaya	Caricaceae
Citrullus lanatus	Watermelon	Cucurbitaceae
Citrus limon	Lemon	Rutaceae
Citrus reticulata	Mandarin	Rutaceae
Citrus sinensis	Orange	Rutaceae
Coffea arabica	Arabica Coffee	Rubiaceae
Cucuis melo	Melon	Cucurbitaceae
Cucumis sativus	Cucumber	Cucurbitaceae
Cucurbita maxima	Pumpkin	Cucurbitaceae
Glycine max	Soyabean	Fabaceae
Ipomoea batatas	Sweet Potato	Convolvulaceae
Lactuca sativa	Lettuce	Asteraceae
Mangifera indica	Mango	Anacardiaceae
Musa spp	Banana	Musaceae
Musa x paradisiaca	Plantain	Musaceae

Nicotiana tabacum	Tobacco	Solanaceae
Phaseolus vulgaris	Beans	Fabaceae
Pinus caribaea	Caribbean Pine	Pinaceae
Piper nigrum	Pepper	Piperaceae
Psidium guajava	Guava	Myrtaceae
Solanum lycopersicum	Tomato	Solanaceae
Solanum melongena	Eggplant	Solanaceae
Solanum tuberosum	Potato	Solanaceae
Sorghum bicolor	Sorghum	Poaceae
Spinacia oleracea	Spinach	Chenopodiaceae
Vigna unguiculata	Cowpea	Fabaceae
Zingiber officianale	Ginger	Zingiberaceae

Annex 3: Integrated Pest Management (IPM) Approaches to FAW Control

International Maize and Wheat Improvement Centre (CIMMYT). Fall Armyworm in Africa: A Guide for Integrated Pest Management. January 2018

There are five main elements of the CIMMYT IPM approach to FAW control:

- Monitoring, surveillance and scouting – Chapter 2
- Pesticide use and pesticide hazard management – Chapter 3
- Host plant resistance – Chapter 4
- Biological control and biorational pesticides – Chapter 5
- Low cost agronomic practices and landscape management approaches – Chapter 6

Monitoring, Surveillance and Scouting

Monitoring, surveillance, and scouting are critical activities necessary for successful implementation of an effective IPM programme. Predicting when a pest will be present and then assessing the level and severity of an infestation allows timely mitigation of the problem using the fewest and safest interventions to effectively and economically guard against yield loss while minimising harm to the environment. The guidelines include: (i) protocols for the use of pheromone traps to detect FAW; (ii) field scouting protocols; and (iii) guidance on determining whether and when to apply chemical control options, based on monitoring and scouting action thresholds.

Pesticide Hazard and Risk Management

The guidelines recognise that pesticide use is likely to be justified in some circumstances. However, expertise in efficient pesticide application is limited in many parts of Africa. Ineffective application can result in some pest reduction, but can also cause harm to beneficial insect populations, and can lead to increased pest population pressure. It can also result in unacceptable impacts to human health. Regulatory authorities have limited capacity to phase out highly hazardous compounds and replace them with economic, efficacious, and lower-risk chemicals.

The guidelines therefore seek to provide: (i) information on barriers to and opportunities for IPM implementation and effective pesticide management; (ii) accessible and practical IPM guidelines; (iii) discussion of how pesticides can fit within a prototype IPM guideline; (iv) identification of pesticides for which risks to human health and the environment are likely to exceed potential benefits; and (v) a summary of simple steps that may minimise risks for other pesticides.

Host Plant Resistance

Developing and deploying effective host plant resistance (HPR) is one of the pillars of an effective IPM. HPR is particularly needed in the African context, where a majority of the farmers are smallholders with limited access to safe and affordable FAW control options. There have been considerable efforts in the Americas to breed for FAW resistance, but similar efforts are just beginning in Africa.

To facilitate deployment of HPR as part of IPM strategies the guidelines provide: (i) background information on sources of native and transgene-based germplasm which can potentially offer FAW resistance; (ii) FAW insect-rearing and artificial infestation protocols; and (iii) a harmonised, reliable, and efficient germplasm screening and rating protocol. The use of genetically modified maize with insecticidal properties (Bt maize) is one option that offers good prospects for FAW control.

Biological Control and Biorational Pesticides

Biological control is defined as "the action of living organisms (parasites, predators, or pathogens) for regulating the population of another organism at densities less than those that would occur in their absence". As an invasive species FAW arrives without most of the naturally occurring biocontrol agents that are present in its indigenous range. The guidelines on biocontrol of FAW in Africa include: (i) how to recognise natural enemies of FAW (insects, viruses, fungi, bacteria, nematodes); (ii) the use of botanical pesticides; (iii) protocols for monitoring biological control agents; (iv) procedures for rearing natural enemies of FAW; (v) use of pheromone traps; and (vi) awareness raising and training for farmers and extension agents.

Agronomic Practices and Landscape Management Approaches

In addition to host plant resistance, biological control, and judicious application of chemical pesticides, a number of low-cost cultural practices and landscape management options can be implemented as part of an effective IPM strategy. Such approaches can be particularly relevant to smallholders who lack financial resources to purchase improved seed, pesticides, or other relatively expensive agricultural inputs. The guidelines present general agro-ecological best practices for pest control in maize-based farming systems common in sub-Saharan Africa including: (i) improving plant health to better withstand pest attack; (ii) optimizing planting time and rotations to escape pest pressure; and (iii) creating sustainable local ecosystems that are inhospitable to FAW.

Food and Agriculture Organisation (FAO). FAO Guidance Note 4. How to Manage Fall Armyworm: A Quick Guide for Smallholders.

The Quick Guide summarizes some of the key concepts and practices that smallholders around the world are trying and using to sustainably manage FAW. It is based on valuable experiences and lessons learned from smallholder maize farmers in Mesoamerica for managing FAW and includes four main tools: prevention, monitoring, knowledge and action.

Prevention

While it is very difficult to completely eliminate FAW from fields, there are actions that farmers can take to reduce infestation and impact. Some key first steps include:

- Use high quality seed. The seed should germinate well, be disease-free and be of the variety the farmer wants to plant. Good pest management depends on healthy plants.
- Avoid late planting or staggered planting (plots of different ages). Female moths have a favourite stage of maize to lay eggs on. If your field is one of the few late-planted plots, all the female moths in a region will come to your plot, where she will lay her eggs.
- Increase plant diversity in your plots. Plants emit chemicals that can attract or repel FAW moths. If a plot of land has a mixture of varieties or crops, the adult moths may not land on maize plants to lay her eggs. Some plants are unattractive to FAW moths such as cassava, but also include non-crop plants, whose sole function in the cropping system is to repel FAW moths from maize plants. Plant diversity can also increase the populations of farmers' friends –organisms that are naturally in the environment and can kill a high proportion of FAW eggs and caterpillars.

Monitoring

Farmers should visit their fields frequently to observe, learn, and take action. Beginning one week after planting and at least once a week, farmers should walk through their fields every 3-4 days. While doing this, they should observe:

- General health of the plants: Do they have a nice dark green colour (indicating good nutrition)? Do they appear moisture-stressed? Are there signs of damage (from FAW, other insects, or diseases)? Are there weeds (especially striga)?
- If there is FAW damage, then check 10 consecutive plants in 5 locations of the field. Look into the whorl (3-5 young leaves) and see if there are holes in the leaves in the whorl and fresh frass. Look for creamy or grey egg masses located on leaves and sometimes stems. Look in early morning or evening hours for young larvae and larvae with the inverted "Y" and four dark spots forming a square (on the second to last body segment).
- If you have access to the FAMEWS application (see Box 2 below), input data on the percent of plants currently infested with FAW while scouting your fields.
- Look for presence of farmers' friends (ants, wasps, larvae killed by pathogens).

Box 2 FAMEWS Mobile App

FAMEWS mobile app is an application for smartphones. The app should be used every time a field is scouted and pheromone traps are checked for FAW. The app has these parts:

- data entry: to collect, record and transmit: scouting data, including basic farm data, manual or scouting data and immediate advice; and trap data.
- IPM education
- digital library
- chat to share experiences
- expert resources

Data are entered by making selections from drop-down lists. Each item provides a useful explanation that, in some cases, includes photos – for example, of different pests and natural enemies to help the user enter accurate data. The app is extremely intuitive, easy and fast to use. It is currently available in 29 languages and can include further languages upon demand. FAMEWS can be downloaded for free from the Google Play Store.

To ensure the accurate collection of high-quality and reliable data, standardized protocols have been developed as Guidance Notes for scouting and checking pheromone traps and these are available in the application.

Source: http://www.fao.org/fall-armyworm/monitoring-tools/famews-mobile-app/en/

Knowledge

Maize plants can compensate for certain levels of foliar damage without losing much yield. Not all FAW damage results in lower yields. farmers' friends (the natural enemies of FAW) can be very important in naturally controlling FAW – studies have found up to 56 percent of FAW larvae naturally killed by farmers' friends. Key to good FAW control is attracting and keeping farmers' friends in the fields.

Effective control does not have to be fast. Parasitized of infected larvae may be alive, but stop feeding. If FAW are not feeding, they are not causing damage to your crop.

Chemical insecticides are expensive. Their use is probably not economically justifiable for smallholder African maize farmers. Some also present high human health risks. Some older types of pesticides, which have been banned from use due to human health risks in many countries, are being used by smallholder maize farmers. Many pesticides kill farmers' friends, those predators, parasitoids, and pathogens that can naturally kill a large proportion of FAW eggs and caterpillars.

Action

Possible actions to manage FAW include: (i) mechanically killing FAW eggs and young larvae; (ii) recycling FAW pathogens; (iii) attracting predators and parasitoids such as ants; and (iv) using local substances applied directly to the whorl of infested plants.

Annex 4: Crop Production Statistics in Study Countries

Sources:

Department of Agriculture. Report on the Fiji National Agricultural Census 2009

Samoa Bureau of Statistics (2016). Agricultural Survey 2015 Report

Solomon Islands National Statistics Office (November 2019). Report on National Agricultural Survey 2017

MAFFF, TSD and FAO. 2015 Tonga National Agricultural Census Thematic Report and Main Report

Vanuatu National Statistics Office. 2016 Post-TC Pam Mini Census Report Volume 1, Basic Tables

Vanuatu National Statistics Office. Census of Agriculture 2007

FAO statistics www.fao.org/faostat/en/#home

Fiji Agricultural Census Data 2009

Table 1: Area, Production and Sales of Temporary Crops at National Level

Susceptible to FAW　　Highly Susceptible to FAW

Crop	Farms With Crop	ha	Prod'n (tonnes)	t/ha	Value FJD'000	Value FJD/ha	Value USD/ha
Cassava	38,757	15,447	58,772	3.8	21,007	1,360	641
Dalo	37,106	15,195	56,645	3.7	49,522	3,259	1,537
Rice	2,821	3,624	4,288	1.2	891	246	116
Yams	6,565	851	565	0.7	179	211	99
Watermelon	2,715	842	2,781	3.3	2,638	3,134	1,478
French beans	2,992	639	869	1.4	539	843	398
Tomatoes	3,045	622	1,529	2.5	1,423	2,289	1,080
Cowpea	2,885	598	1,560	2.6	947	1,583	747
Eggplant	3,424	571	1,693	3.0	716	1,253	591
Sweet potato/Kumala	3,747	558	1,271	2.3	541	968	457
Maize	1,961	536	802	1.5	590	1,101	519
Chinese cabbage	2,123	389	996	2.6	778	2,002	944
Okra/Bhindhi	1,678	388	912	2.4	686	1,768	834
Dalo ni Tana	2,981	365	613	1.7	211	579	273
English cabbage	1,308	312	799	2.6	1,088	3,486	1,644
Pumpkin	1,424	303	932	3.1	461	1,523	719
Ginger	582	217	1,946	9.0	1,490	6,860	3,236
Kawai	1,155	172	120	0.7	11	62	29
Tobacco	324	109	228	2.1	203	1,865	880
Peanuts	344	108	72	0.7	96	888	419
Capsicum	494	88	86	1.0	126	1,441	680
Other vegetables	348	81	46	0.6	22	271	128
Tivoli/yam	572	61	122	2.0	259	4,243	2,002
Amaranthus	341	37	23	0.6	16	438	207
Gourd	119	32	105	3.2	63	1,935	913
Carrot	187	17	44	2.6	18	1,047	494
Total	**119,998**	**42,162**	**137,815**		**84,521**		
Total Highly Susceptible	4,782	4,159	5,090		1,481		
Total Susceptible	25,422	5,425	14,804		11,034		
Total Non-Susceptible	89,794	32,577	117,921		72,006		

Source: 2009 Agricultural Census Table 3.1

Table 2: Area and Production of Sugarcane at Province and National Level

Susecptible to FAW　　Highly Susceptible to FAW

Province	Farms with Sugarcane	Planted area (ha)	Product--ion (t'000)	t/ha
Ba	8,087	27,641	1,140	41
Macuata	7,897	17,032	571	34
Ra	1,866	5,856	258	44
Nadroga	1,679	6,444	216	34
Cacaudrove	82	204	14	66
Total	**19,611**	**57,177**	**2,199**	**38**

Source: 2009 Agricultural Census Table 3.20

Table 3: Area, Production and Sales of Permanent Crops at National Level

Susceptible to FAW — Highly Susceptible to FAW

Crop	Farms With Crop	ha	Prod'n (tonnes)	t/ha	Value FJD'000	Value FJD/ha	Value USD/ha
Coconut/Copra	2,755	15,009	10,634	1	3,244	365	172
Yaqona/Kava	21,306	8,884	6,067	6	66,395	61,094	28,818
Banana	4,261	1,087	3,392	3	2,582	2,376	1,121
Pinapple	914	445	2,829	8	1,866	5,257	2,480
Duruka	1,340	355	539	2	762	2,549	1,202
Cocoa	80	299	39	0	16	67	32
Plantain	1,684	242	619	3	401	1,828	862
Pawpaw/Papaya	465	220	335	2	347	2,319	1,094
Chillies	1,220	150	269	2	383	2,644	1,247
Oranges	13	145	59	1	47	436	205
Voivoi	765	108	251	3	523	5,931	2,797
Bele	768	88	251	3	32	358	169
Masi	233	47	41	1	267	6,572	3,100
Rourou/Taro leaves	261	41	136	4	81	2,153	1,016
Kura/Noni	13	37	6	0	12	716	338
Other fruit	74	16	0	0	0	1	1
Dhania/Corriander	111	16	3	0	3	227	107
Lemon	70	15	12	1	47	4,789	2,259
Other spices	38	10	0	0	1	149	70
Breadfruit	81	9	10	2	2	277	131
Passion fruit	33	7	1	0	1	439	207
Ota (fern)	36	3	18	9	16	8,241	3,887
Other citrus	10	2	25	41	1	833	393
Mandarin, Tangerine	13	1	70	0	7	0	0
Total	**36,544**	**27,233**	**25,607**		**77,036**		
Total Highly Susceptible							
Total Susceptible	9,066	2,213	5,295		4,575		
Total Non-Susceptible	27,478	25,020	20,312		72,460		

Source: 2009 Agricultural Census Table 3.10

Samoa Agricultural Survey Data 2015

Table 4: Number of Agricultural Households Growing Crops

	2009	2015	
No of agricultural households	23,164	28,119	
No of households growing crops	19,358	27,359	97% of all HHs in Samoa
No of crop households producing mainly for sale	728	1,045	

Table 5: Number of Households and Area of Temporary Crops

Susceptible to FAW | Highly Susceptible to FAW

Crop	No HHs	ha	Acres
Taro	18,347	5,238	12,938
Yam	16,533	3,190	7,879
Laupele	16,864	3,089	7,630
Ta'amu	13,446	1,283	3,169
Pineapple	9,903	1,123	2,775
Cassava	5,648	925	2,284
Pumpkin	8,578	910	2,247
Tomato	8,760	828	2,045
Eggplant	11,526	653	1,613
Cucumber	5,772	470	1,160
Chinese cabbage	1,788	423	1,046
Taro palagi	3,971	251	619
Umala/sweet potato	872	106	261
Bean	5,975	70	174
Green pepper	789	67	166
Watermelon	429	65	160
Spring onion	1,517	60	148
Peanut	452	29	71
Lettuce	244	10	24
Watercress	135	4	10
Brown onion	146		
Ginger	14,589		
Chilli	10,433		
Sweet corn	316		
Total	157,033	18,793	46,419
Total Highly Susceptible	316		
Total Susceptible	69,838	3,257	8,045
Total Non-Susceptible	86,879	15,536	38,374

Source: 2015 Samoa Agricultural Survey Table 2.1

Table 6: Number of Households and Area of Permanent Crops

Susceptible to FAW | Highly Susceptible to FAW

Permanent Crops	No HHs	ha	Acres
Coconut	21,242	29,898	73,847
Banana	23,629	4,313	10,654
Cocoa	17,973	2,072	5,118
Breadfruit puou	20,685	1,474	3,642
Breadfurit maafala	18,238	1,021	2,523
Other breadfruit	14,594	739	1,826
Coffee	1,266		
Rambutan	5,806		
Nonu	17,432		
Starfruit	2,240		
Mango	21,366		
Avocado	10,145		
Vi	12,124		
Orange	12,505		
Lemon	18,004		
Tahitian lime	5,174		
Papaya	21,907		
Sasalapa	7,752		
Apiu	3,944		
Vanilla	235		
Mangosteen	46		
Total	**256,307**	**39,518**	**97,610**
Total Highly Susceptible			
Total Susceptible	102,585	4,313	10,654
Total Non-Susceptible	153,722	35,205	86,956

Source: 2015 Samoa Agricultural Survey Table 2.2

Solomon Islands National Agricultural Survey 2017

Table 7: Number of Agricultural Households, Size of Landholdings and Livelihood Activities

No of households with agricultural holdings	111,117
Population of households with agricultural holdings	589,294
Total area of household agricultural holdings (ha'000)	1,159
Average landholding per agricultural household (ha)	10.4
No of households engaged in:	
Growing crops	100,979
Forestry	55,107
Fisheries	43,715
Rearing livestock	43,701
Handicrafts	13,707
Retail trading	13,648
Aquaculture	1,009
Other agricultural activities	33,470

Table 8: Number of Households and Area of Major Crops

Susecptible to FAW | Highly Susceptible to FAW

Major Cash Crops	No of HHs	ha	ha per HH
Coconut	38,296	28,104	0.7
Cocoa	17,847	18,987	1.1
Subtotal	**56,143**	**47,091**	**0.8**
Major Vegetables/Root Crops			
Kumara/Sweet Potato	78,133	26,809	0.3
Cassava	74,076	24,313	0.3
Slippery cabbage	44,272	7,070	0.2
Taro	46,390	5,296	0.1
Eggplant	12,222	5,166	0.4
Subtotal	**255,093**	**68,654**	**0.3**
Major Fruits			
Pomelo	1,398	10,468	7.5
Star fruit	5,645	2,773	0.5
Banana	60,469	7,684	0.1
Papaya	17,300	1,568	0.1
Breadfruit	5,190	1,371	0.3
Subtotal	**90,002**	**23,864**	**0.3**
Total	**401,238**	**139,609**	
Total Highly Susceptible			
Total Susceptible	169,522	51,695	
Total Non-Susceptible	231,716	87,914	

Table 9: Total Crop Area, Tonnes Sold and Value of Sales

Susecptible to FAW — Highly Susceptible to FAW

Crop	ha	Tonnes sold	Value of Sales		
			SBD'000	SBD/t	USD/t
Coconut	28,104	10,742	99,086	9,225	1,129
Kumara/Sweet Potato	26,809	981	32,906	33,561	4,108
Cassava	24,313	674	22,295	33,084	4,049
Cocoa	18,988	2,255	57,501	25,503	3,122
Pomelo	10,468	11	14	1,305	160
Cut nut	7,768	16	162	10,306	1,261
Banana	7,684	360	11,337	31,483	3,853
Other	7,678	757	10,031	13,259	1,623
Slippery cabbage	7,070	1,181	9,770	8,271	1,012
Taro	5,296	784	9,887	12,605	1,543
Eggplant	5,166	55	532	9,652	1,181
Betelnut	4,655	274	65,971	241,209	29,524
Pana	3,157	1,109	4,599	4,146	507
Yam	3,138	524	6,041	11,522	1,410
Star fruit	2,773	7	37	5,211	638
Papaya	1,568	41	266	6,447	789
Kakake	1,563	35	187	5,329	652
Breadfruit	1,372	14	537	39,778	4,869
Konkong	1,364	173	2,795	16,144	1,976
Pineapple	1,318	307	1,697	5,532	677
Tomato	1,292	122	602	4,934	604
Cucumber	1,102	66	1,433	21,712	2,658
Guava	712	13	320	25,129	3,076
Pumpkin	706	42	363	8,757	1,072
Peanut	639	282	5,084	18,059	2,210
Edu	576	67	886	13,266	1,624
Inkori	537	13	23	1,740	213
Lemon	534	13	140	11,024	1,349
Malayan apple	476	40	321	7,970	976
Shallot	457	67	1,692	25,401	3,109
Oil palm	369	7	200	29,910	3,661
Ngali nut	367	2	119	56,571	6,924
Mango	362	22	751	33,833	4,141
Kava	347	2	909	439,082	53,743
Chinese vegetables	297	109	2,608	23,862	2,921
Capsicum	252	51	522	10,195	1,248
Orange	200	5	55	10,960	1,341

Table 9 (Continued): Total Crop Area, Tonnes Sold and Value of Sales

Crop	ha	Tonnes sold	Value of Sales SBD'000	SBD/t	USD/t
Rambutan	194	26.2	388	14,794	1,811
Head cabbage	177	1.1	29	26,667	3,264
Mandarin	177	29.5	574	19,471	2,383
Black pepper	119	2.5	81	32,240	3,946
Alite	116	0.7	12	17,143	2,098
Turnip	109	0.9	9	9,889	1,210
Soursop	100	2.3	20	8,565	1,048
Avocado	93	3.0	93	30,900	3,782
Boneo	80	4.5	22	4,867	596
Mushroom	73				
Chillies	66	0.7	263	404,455	49,505
Ginger	65	3.4	159	46,647	5,710
Chestnut	59				
Pitpit	43	0.7	6	8,286	1,014
Kang kong	40	3.6	150	41,778	5,114
Jackfruit	33	6.2	38	6,048	740
Lettuce	31	0.8	30	37,125	4,544
Ofen'a	26		32		
Aerial yam	16	0.2	2	9,500	1,163
Fern	12	28.0	119	4,246	520
Sand paper	12	0.9	6	7,333	898
Water cress	5	0.6	45	75,500	9,241
Crown of thorns	4				
Passion fruit	4	0.0	2	300,000	36,720
Croton	1				
Land cress	1				
Orchids	1				
Turmeric	1	0.0	8	200,000	24,480
Okra	0.1				
Radish	0.1	0.3	6	19,938	2,440
Coffee (Robusta)		1.2	35	30,086	3,683
Heliconia		0.8	15	20,000	2,448
Total	**181,135**	**21,338**	**353,822**		
Total Highly Susceptible					
Total Susceptible	58,629	2,168	57,158		
Total Non-Susceptible	122,506	19,170	296,664		

Source: 2017 Solomon Islands Agricultural Survey Table 6.10

Table 10: Area of Crops Grown

Susceptible to FAW | Highly Susceptible to FAW

Crop	ha	Acres
Coconuts a/	4,800	11,856
Cassava/Manioke	4,132	10,207
Yam/Ufi	2,152	5,315
Yautia/Talo Futuna	1,038	2,565
Sweet Potato/Kumala	770	1,901
Swamp Taro/Talo Tonga	659	1,627
Kava	509	1,257
Paper mulberry/Hiapo	306	757
Vanilla	256	632
Giant taro/Kape	249	616
Plantain/Hopa	199	492
Pineapple/Faina	184	454
Watermelon/Meleni	168	416
Banana/Siaine	114	282
Peanut	105	259
Cooking banana/Pata	50	124
Tomato	45	111
Squash	34	84
Pandanus/Louakau	31	77
Pele	15	38
Corn/Kane	15	37
Tobacco	15	37
Pumpkin	13	31
Papaya	11	28
Capsicum	10	24
Head cabbage	9	22
Granadilla	8	19
Chinese cabbage	7	18
Coffee	7	18
Carrot	7	17
Passion fruit	6	15
Cucumber	5	13
Guava	3	7
Breadfruit	2	6
Angoango	2	4
Onion	2	4
Rose apple	2	4
Chilli	1	3
Irish potato	1	3
Lettish	1	3
To	1	3
Mango	0.8	2
Radish	0.8	2
Eggplant	0.4	1
Litchi	0.4	1
Orange	0.4	1
Total	15,949	39,393
Total Highly Susceptible	15	37
Total Susceptible	1,563	3,860
Total Non-Susceptible	14,371	35,496

a/ Area of coconuts estimated from No of palms/150 palms/ha

Vanuatu Census of Agriculture 2007

Table 11: Number of Temporary Crop Plants

Susceptible to FAW | Highly Susceptible to FAW

	No Plants ('000)		
	Total	Gardens	Other
Taro - Island	6,944	6,917	27.1
Yam	6,877	4,205	2,672.0
Kava	5,906	5,831	75.1
Cassava/Manioc	2,828	2,819	9.0
Taro - Fiji	2,275	2,249	26.0
Cabbage - island	2,037	2,033	3.5
Banana	1,657	1,579	78
Corn	1,474	1,472	2.0
Plantain	1,365	1,358	7.1
Sweet potato/Kumala	1,311	1,310	0.7
Spring onion	642	641	1.2
Pumpkin	641	641	0.1
Sugarcane	568	568	0.4
Papaya	563	559	3.7
Cabbage - Chinese	329	329	
Taro - Navia	320	317	3.3
Tomato	307	307	0.1
Capsicum	289	289	0.5
Cabbage - round	272	272	
Ginger	234	233	1.0
Carrot	183	183	
Onion	182	182	
Tobacco	180	175	4.9
Lettuce	164	164	
Cucumber	164	164	0.2
Bean	163	163	0.05
Chili	131	131	
Naviso	130	129	0.3
Garlic	121	121	
Watermelon	109	109	0.0
Peanut	78	78	
Other	58	58	
Leaf spices	45	45	0.1
Eggplant	13	13	
Pineapple	8	5	3.0
Strawberry	8	8	
Radish	5	5	0.0
Total	38,582	35,664	2,919
Total Highly Susceptible	568	568	0
Total Susceptible	5,565	5,552	12
Total Non-Susceptible	32,449	29,543	2,906

Source: 2007 Census of Agriculture Table 4.17

Table 12: Number of Permanent Trees

(light shading)	Susceptible to FAW
(dark shading)	Highly Susceptible to FAW

Crop	Trees '000
Navele	334
Chestnuts	228
Breadfruit	219
Orange	172
Mango	169
Mandarin	163
Nangae	145
Grapefruit	130
Other	114
Avocado	101
Natapoa	84
Nause	72
Lime	61
Total	**1,992**
Total Highly Susceptible	
Total Susceptible	695
Total Non-Susceptible	1,298

Source: 2007 Census of Agriculture Table 4.19

Vanutau Post TC Pam Mini-Census 2016

Table 13: Number of Households Growing Selected Crops

Susceptible to FAW
Highly Susceptible to FAW

Crop	No of HH
Banana	45,495
Manioc/cassava	45,020
Island cabbage	43,271
Papaya	38,385
Yam	33,052
Kumala	32,799
Fijian taro	31,628
Corn	30,571
Island/water taro	25,240
Coconut	23,164
Kava	17,893
Peanut	10,315
Cocoa	9,000
Tahitian lime	2,004
Coffee (Robusta)	1,953
Vanilla	1,063
Pepper	337
Rice	189
Total	391,379
Total Highly Susceptible	30,760
Total Susceptible	129,335
Total Non-Susceptible	231,284

Source: 2016 Mini-Census Table 3.32