Food and Agriculture Organization of the United Nations

A risk assessment for the introduction of African swine fever into Tuvalu

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A risk assessment for the introduction of African swine fever

into Tuvalu

by

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Contents

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Abbreviations and acronyms

ASF	African swine fever
DOA	Department of Agriculture, Ministry of Local Government and Agriculture, Tuvalu
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
OIE	World Organisation for Animal Health
PCR	polymerase chain reaction
PICs	Pacific Island Countries
FAO RAP	FAO Regional Office for Asia and the Pacific
FAO SAP	FAO Subregional Office for the Pacific Islands
SEA	Southeast Asia
TAD	transboundary animal disease
WAHIS	World Animal Health Information System

Executive summary

This report describes a risk assessment mission in Tuvalu undertaken by the EpiCentre, School of Veterinary Sciences, Massey University and the Food and Agriculture Organization of the United Nations (FAO) under FAO Technical Cooperation Programme (TCP/SAP/3802). The overall aim was to evaluate the risk of introducing the African swine fever (ASF) virus into Tuvalu and use the findings to propose recommendations that enable professionals, communities and key stakeholders to implement prevention and mitigation measures to reduce the impacts of ASF incursion.

ASF is a highly contagious viral disease in domestic and wild pigs. It has emerged from Africa, spreading to eastern Europe, China and Southeast Asia. Due to ASF outbreaks in Asia and Papua New Guinea, Pacific Islands countries now prioritize preventing the introduction of ASF. A risk assessment of ASF virus introduction is a prerequisite for deciding which preventive actions would be most effective. The assessment of risk was conducted using the OIE import risk analysis framework. The most likely pathway for introducing ASF virus into Tuvalu was importing unauthorized pork products that international arrival passengers may bring in via airport or seaport. Should infected products enter Tuvalu, there is a distinct pathway for exposure because pigs are routinely fed food scraps (swill) from households. The likelihood of transmission of ASF virus to other susceptible pigs was considered extremely high due to the lack of farm biosecurity and the presence of feral pigs.

The assessment method was a systematic, qualitative import risk analysis of ASF virus introduction to Tuvalu. Results provide information about high-risk areas for ASF introduction, exposure and spread in Tuvalu. They also identify gaps in control and prevention measures. The following steps are being proposed to minimize the likelihood of entry and exposure and the consequence of ASF virus introduction.

Key recommendations are to:

1. Increase awareness of incoming passengers about meat products and fomites that can carry ASF virus and instruct passengers to declare such materials or whether they have visited any farms recently (30 days) to the quarantine officer. Passengers can dispose of their food items in designated bins. Non-compliance shall be penalized.

2. Strengthen quarantine procedures and infrastructure at the border to ensure that all baggages are manually searched thoroughly upon arrival. Installation and application of X-ray baggage scanner are recommended.

3. Ensure appropriate disposal of confiscated products through the incinerator.

4. Encourage households and restaurants to separate meat from vegetable waste and ban the supply of meat leftovers to pig owners.

5. Ensure sufficient cooking of swill (core temperature of 70°C for 30 minutes)

6. Increase awareness of pig owners and villagers about the ban on meat waste feeding, especially pork meat.

7. Educate stakeholders on ASF clinical signs and prompt reporting by pig owners/animal workers/general public of signs of disease to the Livestock unit of Division of Agriculture.

8. Promote and strengthen farm biosecurity practices i.e. proper fencing of pigs, apply appropriate hygiene and sanitation measures.

9. Prepare an emergency response plan for ASF with implementation and financial plan.

10. Strengthen biosecurity legislations/regulations to include ASF and other transboundary animal diseases preventive and response measures, including the ability to fine companies/people who break these regulations where they exist.

11. Encourage a multi-sectoral and multidisciplinary approach (One health) to address biosecurity threats of ASF and other TADs.

1. Introduction

1.1 BACKGROUND

African swine fever (ASF) is a highly infectious transboundary animals' disease of pigs (Costard *et al*., 2009). ASF virus infected pigs develop severe lethargy, diarrhoea or acute haemorrhagic fever, which typically results in death (Gabriel *et al*., 2011; Gallardo *et al*., 2017). After introducing ASF to Georgia in 2007, the disease has spread to nearly every Eastern European country (Rowlands *et al*., 2008). The situation has been worse in 2018 as ASF was reported in China and rapidly spread to other adjacent Asian countries, causing the loss of more than 6.7 million pigs, mostly as pre-emptive culling (OIE, 2020). The movement of the ASF virus into the Asia-Pacific region poses a risk of ASF introduction to Pacific Island countries (PICs) such as Tuvalu. An outbreak of ASF in Tuvalu would result in high levels of pig mortality which would significantly affect food security in the country as most pigs are kept for subsistence. In addition, the costs associated with safely disposing of animals that die because of the disease and the slaughter and disposal of healthy animals to control the outbreak would be significant.

In early 2020, a pilot project was initiated by the FAO Subregional Office for the Pacific Islands (FAO SAP) based in Apia, Samoa in close collaboration with FAO Regional Office for Asia and the Pacific (FAO RAP) to assess the risk of ASF introduction to Samoa. The mission was completed by EpiCentre, Massey University, New Zealand, of which two consultants visited the country for interviewing government agencies, farmers and stakeholders and delivered a risk assessment report. Given the lack of import risk assessment of ASF in other Pacific countries, the project's scope was expanded to cover the risk for other PICs (Tuvalu and the Federated States of Micronesia) in TCP/SAP/3801.

1.2 MISSION ACTIVITIES

Due to the travel restriction caused by the COVID-19 pandemic, EpiCentre consultants couldn't visit Tuvalu. Therefore, instead of face-to-face interviews administered by EpiCentre consultants, questionnaires were developed (attached in Annex) and administered by the national project coordinator (Mr Sama Sapakuka). The questionnaires were used to collect information from the following agencies:

- Department of agriculture
- Quarantine office (under the Department of Agriculture)
- Custom office
- Marine office
- Aviation office.

The information collected aimed to aid our understanding of the roles and responsibilities of various government agencies and gather information on factors influencing the occurrence and spread of ASF for import risk analysis. For data relating to the introduction pathway, the focus was on what happened before the travel restrictions imposed due to the COVID-19 pandemic.

Questionnaires were also developed to collect information from pig farmers about their farming practices and biosecurity measures in commercial/subsistence pig farms and local pork supply. The questionnaires were used to select pig farmers and staff at the Department of Agriculture pig unit (Vaitupu). The national coordinator also conducted spot checks for imported and local pork products in the supermarket. There are no dedicated pig traders or pig slaughter operations in Tuvalu.

2. African swine fever

2.1 AFRICAN SWINE FEVER VIRUS

African swine fever virus is a double-stranded DNA virus of the Asfarviridae family that cause African swine fever (ASF), an infectious disease in pigs (Costard *et al*., 2013). ASF virus infected pigs develop severe lethargy, diarrhoea or acute haemorrhagic fever, typically resulting in death (Gabriel *et al*., 2011; Gallardo *et al*., 2017). Several genotypes of ASF virus exist, and their virulence varies considerably. Recent genetic characterisation of all the ASF virus known isolates has shown 23 geographically related genotypes with many subgroups. The variability of a segment in the VP-72 gene is used for phylogenetic and molecular epidemiological purposes to identify the source of outbreaks (FAO, 2017).

ASF virus can be isolated from the blood, faeces, urine and nasal/ocular/vaginal excretions of infected pigs up to at least 70 days of infection (de Carvalho Ferreira *et al*., 2012). Depending on the environmental conditions, the virus can also be isolated from the carcasses of infected pigs and/or the soil of the deathbed for up to several months (Fischer *et al*., 2020; Zani *et al*., 2020). In addition, the virus can survive in fresh, salted, dried and frozen meat for months to years (Table 1). In the laboratory, temperatures of 70°C for up to 30 minutes were required to destroy ASF virus (FAO, 2017).

ASF virus can be transmitted directly or indirectly via pig-to-pig, feed-to-pig, fomites-to-pig and wild boar-to-pig pathways (Guinat *et al*., 2016). The most crucial transmission pathway is feeding swill, where swill feeding is common, e.g. China. The incubation period for the virus ranges from 4 to 19 days (OIE, 2019) and the infectious period ranges from 3 to 14 days in experimental studies (Guinat *et al*., 2016). The mortality rate of ASF can be as high as 100 percent, depending on the virulence of the strain and the susceptibility of the pig population (Blome *et al*., 2013).

To date, no treatments or vaccines are available to control ASF. Therefore, rapid and reliable detection is necessary to confirm the disease and implement control measures. Immediate removal of infected carcasses, culling of animals and the slaughter of all in-contact pigs in a contaminated area are the best practice for controlling the spread of ASF (OIE, 2019). Early detection relies on immediate reporting when pigs are observed to have clinical signs consistent with ASF (i.e. dermal haemorrhages, fever, diarrhoea, bleeding from orifices (high mortality) and rapid testing of dead pigs. A PCR based on the VP-72 gene is the test of choice for early detection in peracute, acute or subacute ASF cases. PCR cannot confirm infectivity but can confirm the presence and quantitative information (FAO, 2017).

Table 1. Expected survival time of African swine fever virus in various conditions

Product	Survival time (days)
Pork (with/without bone and grounded)	105
Salted pork	182
Dried pork	300
Smoked pork	30
Frozen pork	1 000
Chilled pork	110
Chilled blood	540
Offal	105
Skin/fat	300
Faeces	11
Contaminated pig pens	30

Source: **FAO**. 2017. African Swine Fever: Detection and Diagnosis - A manual for veterinarians. www.fao.org/3/a-i7228e.pdf

2.2 AFRICAN SWINE FEVER SITUATION

ASF had been an endemic disease only in Africa until 1957 when the first transcontinental case occurred in Portugal (Boinas *et al*., 2011). Although ASF had spread to some European and American countries, the disease was declared to be eliminate in 1995 (except in Sardinia in Italy) (Dixon *et al*., 2020). Almost two decades later, another introduction of ASF virus to Europe was reported from Georgia in June 2007 (Rowlands *et al*., 2008). ASF quickly spread to the Caucasus region (Beltrán-Alcrudo *et al*., 2009) and persisted in the continent mainly via the "wild boar–habitat cycle" that the transmission of ASF occurs directly between wild boars and indirectly through carcasses in the habitats (Chenais *et al*., 2018). Since its re-introduction in 2007, ASF has transmitted to other European countries, including Belarus, Bulgaria, Belgium, the Czech Republic, Estonia, Germany, Greece, Hungary, Italy, Latvia, Lithuania, the Republic of Moldova, Poland, Romania, Serbia, the Slovak Republic and Ukraine (OIE, 2020; Sauter-Louis *et al*., 2021; Schulz *et al*., 2019).

In 2019, ASF virus was reported in China and had rapidly spread to other Asian countries, most likely via illegal importation of pig meat from affected countries (Schulz *et al*., 2019). Since ASF virus was reported in China, outbreaks have been reported in 15 other countries in the Asian Pacific (see Figure 1). Affected countries implemented control measures, such as pre-emptive culling and movement restriction. Between 2018 and 2020, nearly seven million Asian domestic pigs were culled to prevent the spread of ASF. The Ministry of Agriculture and Fisheries of Timor-Leste announced the culling of 100 000 pigs after the confirmation of ASF in September 2019. In January 2022, an outbreak of ASF was reported in Thailand and the government allocated USD 17.3 million to control the disease spread. Due to the geographical proximity to Thailand, the Cambodian government restricted any importation of pigs from its neighbouring countries. ASF outbreaks and followed control measures have severely affected national food security and livelihood, especially poor rural families in many Asian countries. However, ASF control was largely ineffective due to a lack of technical or financial resources.

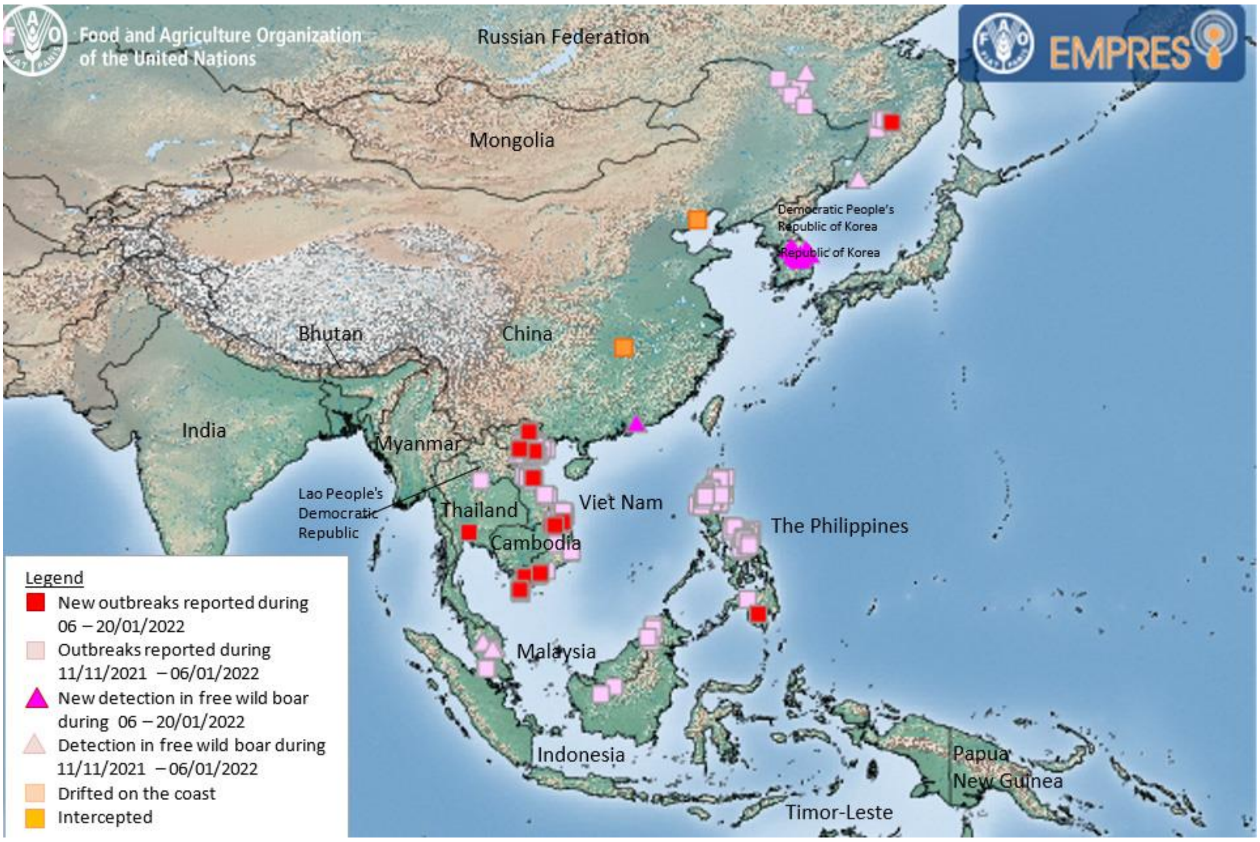

Figure 1. Current situation of ASF in Asia as of January 2022; Source: **FAO**. 2022. *ASF situation in Asia update*. http://www.fao.org/ag/againfo/programmes/en/empres/ASF/situation_update.html#

3. Tuvalu

3.1 GENERAL PROFILE

Tuvalu comprizes nine islands and atolls (e.g. Nanumea, Nanumaga, Niutao, Nui, Vaitupu, Nukufetau, Funafuti Nukulaelae and Niulakita) located in the Polynesia region of the Pacific Ocean. The country is aligned in a northwest-southeast orientation. The nine islands are spread between the latitude of 5° and 10° south and between the longitude of 176° and 180° (Figure 2). The country is approximately 1 000 kilometres north of Fiji and 3 000 kilometres north of New Zealand.

Figure 2. Location of Tuvalu. Source: **United Nations**. 2022. *Geospatial map*. New York. Cited 20 July 2022. www.un.org/geospatial/content/map-world

Tuvalu is one of the smallest countries, with a total land size of about 26 square kilometres. The population size of Tuvalu is 10 645 people (1 626 households), the majority of which are populated on Funafuti island (Tuvalu Central Statistics Division, 2021). The country's gross domestic product (GDP) is estimated to be USD 47.3 million (The World Bank, 2020).

The agricultural sector in Tuvalu plays an important role in food security, nutrition and national economic growth. Most of the households in Tuvalu (1 464 out of 1 626) are engaged in agricultural activities, such as crop production or livestock raising, which contribute to approximately 19 percent of the national GDP (Tuvalu Central Statistics Division, 2021). Along with crop production, livestock raising plays a key role in supporting household livelihoods and providing income, particularly in rural areas.

Raising livestock is a common activity, with more than 80 percent of (1 362 out of 1 626) households keeping either pigs or loose poultry (chicken and ducks) primarily for self-consumption (Tuvalu Central Statistics Division, 2021). Given the subsistence level of livestock production, the government of Tuvalu has been focusing on increasing the productivity of the livestock system to enhance food security and sustainable livelihood. Tuvalu's food security and nutrition depend on enhancing smallholder productivity and border biosecurity to protect against contagious diseases and pests entering the country. In addition, Tuvalu is vulnerable to sea-level rise. The country has already experienced unusually high king tides linked to the flooding of dwellings and saltwater intrusion into freshwater, impacting food security, water, health and general living conditions of the Tuvalu people (Simpson *et al*., 2012).

3.2 PIG SECTOR

The animal production system in Tuvalu is almost exclusively subsistence farming. Therefore, most livestock farms are small-scale holders of pigs and poultry. According to the census conducted in 2017, the total population size of pigs in Tuvalu was 10 894. More than half of the pig populations were located on three islands: mostly in Funafuti (35 percent), followed by Vaitupu (15.4 percent) and Nanumea (14.2 percent). Some domestic pigs have become feral pigs, but the size of the feral pig population is unknown

Pigs in Tuvalu are predominately owned and raised by households. Over 75 percent of households (1 242 of 1 626) raised on average 8.8 pigs (Tuvalu Central Statistics Division, 2021). The only exception to the small-scale holdings is the pig breeding unit (Elisefou station) on Vaitupu. The unit was established with help from the FAO and are operated by the Department of Agriculture on Vaitupu. The unit provides livestock farmers in pig-husbandry and has also imported new breeds from Fiji to be crossed with local breeds. These interventions have increased productivity and household incomes (FAO, 2015).

By-laws in Tuvalu has been passed to prevent the free-ranging of farms; however, the laws are often not followed on the island of Nanumea. Other than that, farmers currently practice no biosecurity measures. If they emerged, the lack of biosecurity measures on farms would favour the spread and maintenance of several pig diseases, including ASF. For example, most pigs are fed a diet consisting of a mix of coconuts and food waste from households (swill). Some households reported cooking swill over an open fire. However, most did not heat treat the swill prior to feeding. A small number of households purchase pig feed imported from Australia. This commercial feed is used as a supplement to the diet.

Table 2. Number of households raising livestock and number of pigs on each island of Tuvalu.

Islands	No. households	No. households raising pigs	No. of pigs	Average pig holding
Nanumea	105	89	1 552	17.4
Nanumaga	93	80	930	11.6
Niutao	116	97	795	8.2
Nui	97	90	941	10.5
Vaitapu	187	173	1 683	9.7
Nukufetau	112	97	690	7.1
Funafuti	849	557	3 772	6.8
Nukulaelae	57	52	490	934
Niulakita	10	7	41	5.9
Total	1 626	1 242	10 894	8.8

Source: **Tuvalu Central Statistics Division**. 2021. *Tuvalu Agriculture and Fisheries Report based on the Analysis of the 2017 Population and Housing Census*. Funafuti, Tuvalu.

The purpose of raising pigs in Tuvalu is primarily for self-consumption. The vast majority (93 percent) of households with pigs reported home consumption (subsistence) as their main purpose for raising pigs. A further 6 percent of households indicated that while mainly for home consumption, they also sold some of their pigs (Table 3). Mostly, these sales are to other households, although there are local Chinese restaurants on the island that are reported to buy pork (Simpson *et al*., 2012).

Among the 1 242 farms, the majority of them (65.9 percent) reported having modern housing (i.e. a pig pen with a concrete floor and corrugate iron roof). A typical subsistence farm in Tuvalu is shown in Figure 3. On the island of Funafuti, most pigs are confined to the communal pig rearing area to the northeast of the main airstrip on Fogafale Islet. Approximately 8 percent of respondents indicated that they did not have any housing (Table 4). These households are likely to be on Nanumea as there are reports that producers on the island are not following the by-laws forbidding the free-range farming of pigs (Thaman *et al*., 2016).

Table 3. Number of households raising pigs by purpose on each island of Tuvalu.

Islands	No. household raising pigs	Home consumption	Home consumption but some for sale	Mainly for sale	Other, e.g. customary
Nanumea	89	87	2	0	0
Nanumaga	80	78	2	0	0
Niutao	97	89	7	0	1
Nui	90	79	11	0	0
Vaitapu	173	166	6	0	1
Nukufetau	97	70	20	3	4
Funafuti	557	532	21	1	3
Nukulaelae	52	47	4	0	1
Niulakita	7	7	0	0	0
Total	**1 242**	**1 155**	**73**	**4**	**10**

Source: **Tuvalu Central Statistics Division.** 2021. *Tuvalu Agriculture and Fisheries Report based on the Analysis of the 2017 Population and Housing Census*. Funafuti, Tuvalu.

Table 4. Number of households raising pigs and pig number by type of animal housing in Tuvalu

Islands	No. household Raising pigs	No. pigs	Average pig holding	Proportion of animal housing (%)
Modern	819	6 517	8.0	65.9
Local	218	2 141	9.8	17.6
Both	102	1 020	11.0	8.2
No housing	103	1 216	11.8	8.3
Total	**1 242**	**10 894**	**8.8**	**100**

Source: **Tuvalu Central Statistics Division.** 2017 *Tuvalu Population and Housing Census (2017).* Funafuti, Tuvalu

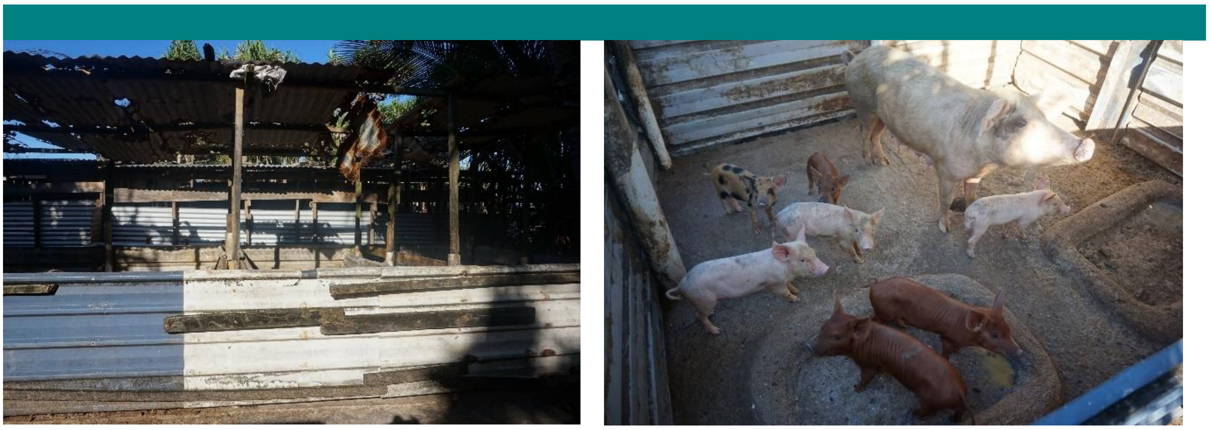

Figure 3. Pigs in a confined system of subsistence farms in Tuvalu; ©FAO

Across the pig production system, most pigs were for household consumption or cultural purposes. Pigs are typically slaughtered at a live weight between 25-50 kg. There are no slaughterhouses, so the animals are slaughtered at home or on-farm and cooked for ceremonial occasions festivities. There is one small privately-owned sausage factory in Funafuti. The pork meat for this sausage factory is supplied by the local pig farmers from their local pig production. It was reported that they produced around 6 000 packs of 400-gram sausages in 2003 (Fifita, 2004). In addition, Tuvalu still imports an unknown quantity of pork meat and pork products (e.g. retail cuts, ham, shoulder, sausage, canned pork, etc.) for local consumption and supply to local restaurants. All pork products are imported from Australia and certified by Australian standards. A summary of the pork marketing chain is shown in Figure 4.

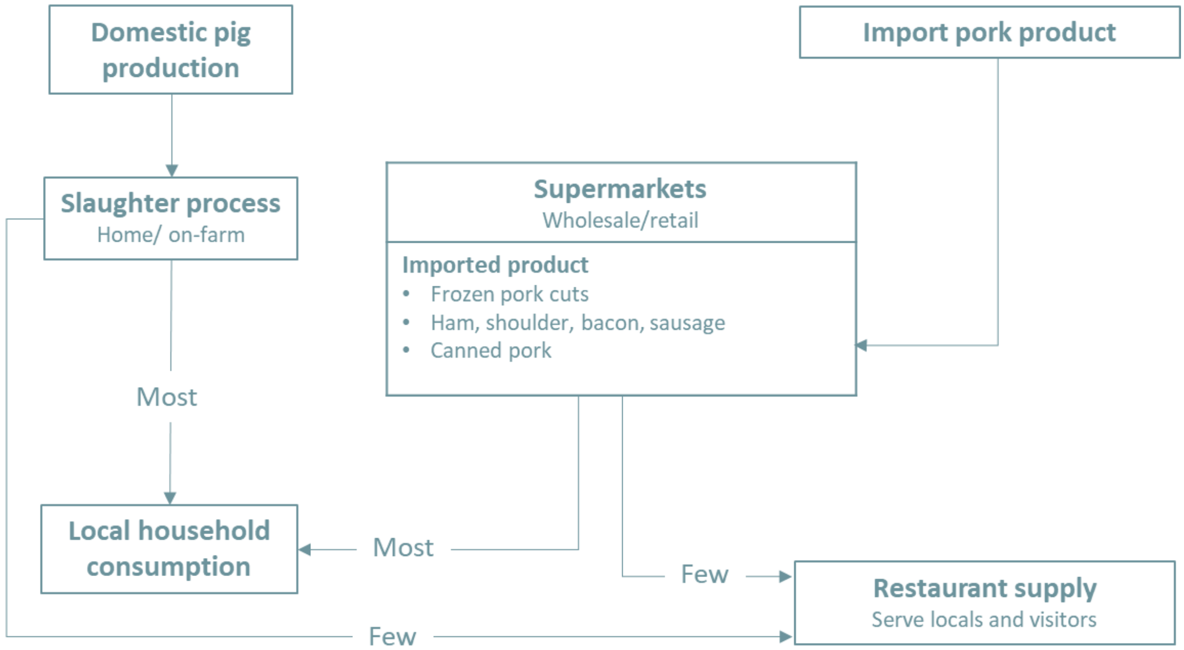

Figure 4. Pork marketing chains. Source: elaborated by the authors

3.3 ROLES OF AGENCIES FOR PREVENTING AND RESPONDING TO AN ASF OUTBREAK

Securing Tuvalu's border against invasive pathogens is the task of the Tuvalu Quarantine office under the Department of Agriculture (DOA). The office liaises with the Health Department, Custom, Aviation and Marine offices. They are responsible for preventing the introduction and spread of unwanted agricultural pests and diseases through passenger arrival, cargo and post. When found, illegally imported animal or animal products are confiscated and destroyed in their high-temperature incinerator at the seaport in Funafuti. Quarantine officers reported that they manually conduct the screening of baggage/cargo to detect prohibited items without any aid of X-rays or detection dogs.

No qualified veterinarian is operating in Tuvalu. It was narrated that a DOA staff is completing a veterinary degree in Fiji and will come back to Tuvalu as soon as the border restriction is lifted. Currently, simple treatment of sick animals and castration services are routinely done by extension officers. The livestock officers occasionally conduct husbandry training programmes at Elisefou and the islands. Three extension officers completed the requirements for the qualification of para-veterinarians under the training programme conducted by the Land Resources Division of the South Pacific Commission (SPC). They are considered 'eyes' and 'ears' of the SPC Veterinarians and are tasked with informing the SPC of emergency needs in Tuvalu that may require support (Tuvalu Department of Agriculture, 2016).

In an animal disease emergency, such as ASF, DOA sanctions provisional measures to verify the outbreak and control its spread. The legal basis for declaring a disease emergency is the Biosecurity Act 2017 and Livestock Disease Act 2008, which the DOA officers enforce. Should an ASF outbreak occur, the DOA would have legal powers to coordinate several government agencies' responses. The Biosecurity Act and Livestock Disease Act allow other parties, such as Police to exercise reasonable force to ensure compliance and provide compensation. Nevertheless, it was narrated that the funds and resources would be limited in responding to ASF incursion.

During an ASF response, DOA will have full authority to apply control measures under the Animal Health Regulation. The Livestock officers will be responsible for:

- Surveillance of animal populations for ASF outbreaks;
- Responding to public enquires about sick animals, investigation and organization of property access for sample submission and submission of samples for laboratory testing;
- Raising awareness amongst communities on the impacts of ASF outbreaks on livelihoods;
- Risk reduction and management of outbreaks;
- Prohibition of animal movements;
- Prohibition of the distribution, sale or use of any animals, animal products or animal-related items;
- Slaughter of animals for disease control purposes to prevent the spread of ASF, instructions for the disposal of animal carcasses;
- Implementation of official control programmes, including disinfection and eradication measures.

4. Import risk analysis

The methodology used in this mission follows the OIE import risk analysis framework (OIE, 2010) and the New Zealand Biosecurity Risk Analysis guidelines (Biosecurity New Zealand, 2006). The terminology used for risk attributes and descriptors is provided in Table 5. The import risk analysis process is shown in Figure 5.

Table 5. Terminology for risk attributes and descriptors

Risk Attributes	
- Negligible	Not worth considering; insignificant
- Non-negligible	Worth considering; significant
Risk Descriptors	
- Very low	Close to insignificant
- Low	Less than normal level
- Medium	Around normal level
- High	Extending above normal level
- Very high	Well above normal level

Source: **Biosecurity New Zealand.** 2006. *Risk Analysis Procedures, Version 1.* Retrieved from https://www.mpi.govt.nz/dmsdocument/2031/direct

4.1 HAZARD IDENTIFICATION

ASF virus is known to be exotic to Tuvalu and identified as a potential hazard. Thus, the main goal for this step is to identify risk products/items from ASF affected countries that could be contaminated with ASF virus and enter Tuvalu. According to the latest OIE World Animal Health Information System (WAHIS), ASF was reported in Africa, the Eastern part of Europe, Russia and 16 countries in Asia, including Bhutan, Cambodia, China, Democratic People's Republic of Korea (the), India, Indonesia, Lao People's Democratic Republic (the), Malaysia, Mongolia, Myanmar, Papua New Guinea, Republic of Korea (the), Thailand, the Philippines, Timor-Leste and Viet Nam. (FAO, 2022; OIE, 2020). ASF virus can be transmitted directly or indirectly via pig-to-pig, feed-to-pig and fomites-to-pig (Guinat *et al*., 2016). It is assumed that live pigs, pork meat products, pig feed and contaminated fomites from these regions would pose a non-negligible risk of ASF introduction into Tuvalu.

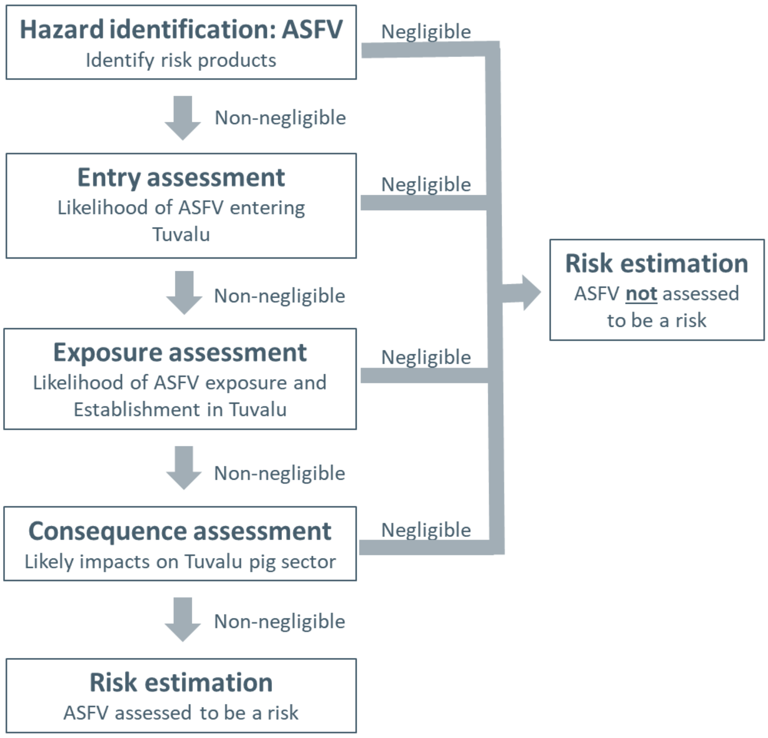

Figure 5. Import risk analysis process. Source: elaborated by the authors

4.2 ENTRY ASSESSMENT

Tuvalu is an island country located some distance from its nearest neighbour. Therefore, ASF virus entry into Tuvalu would be limited to the international air and seaports located on Funafuti Island. While the other Islands have seaports, responses indicated that these ports have no interactions with international vessels. The ASF virus could enter the country through contaminated pork meat products and fomites from the passenger. Figure 6 summarizes the pathway by which ASF virus might enter Tuvalu and infect local pigs.

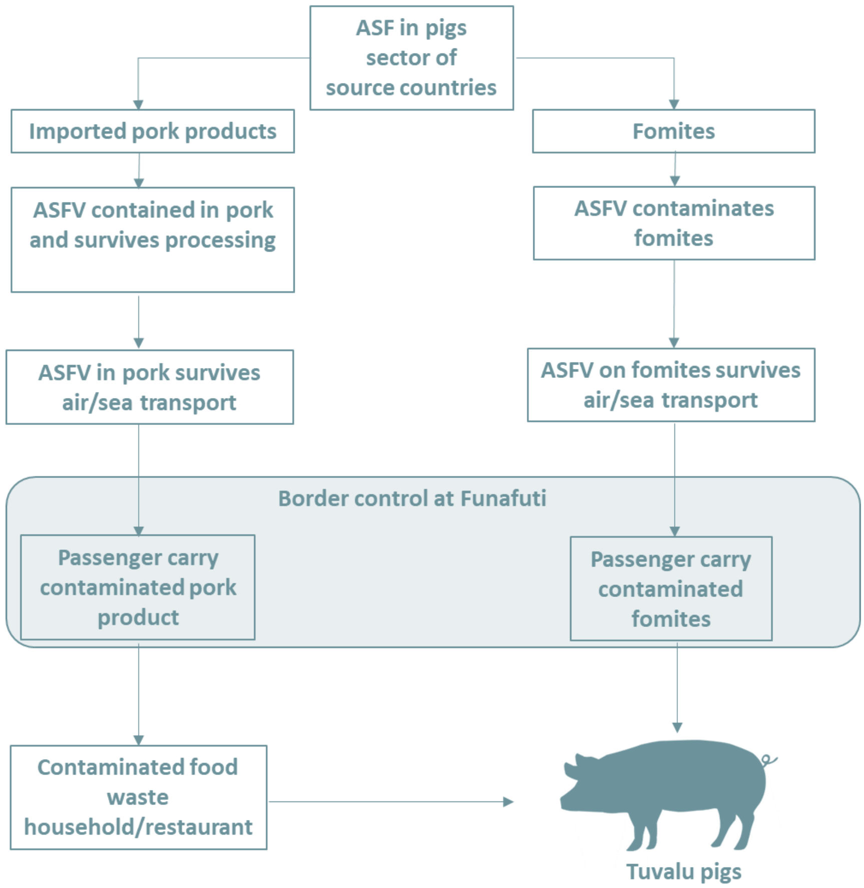

Figure 6. ASF virus risk pathways into Tuvalu. Source: Elaborated by the authors

While live pigs have been imported historically, this no longer happens according to responses from government agencies and spot checks. According to survey responses, the last shipment of pigs was from Fiji 20 years ago. The pig feed is imported from Australia or Fiji, which are currently free of ASF. Pork meat and meat products, i.e. pork cuts, ham, shoulder and pork luncheon meat, are imported from Australia. It was noted that pork luncheon products were manufactured in China, but they were imported through Australia and complied with the Australian food standards. Reports from several countries, including Australia, Malaysia and the Philippines, have shown positive DNA tests (PCR) for ASF virus in Chinese pork luncheon products. However, the ASF virus would be inactivated if the meat was processed per Australian standards, requiring high temperature (up to 115°C) and pressure treatment. Therefore, a product that meets the Australian food standards is unlikely to pose a risk of ASF virus introduction.

Another pathway for introducing ASF virus is passengers arriving by air into Tuvalu. Passengers arriving by air may be carrying pork or pork products with ASF virus. They may also have equipment that could have ASF virus on it. All passengers must fill in arrival cards and declare whether they carry food items. There is also a practice of manually searching the luggage of every arriving passenger. However, there is still the possibility a passenger will not declare, and pork products could be missed in the search. Information from the quarantine service indicated that pork products posing a risk of ASF introduction were not always confiscated. Unconstrained imports of pork products, either accidentally by tourists or intentionally by smuggling the products for personal or commercial use, presents a continuous threat for ASF introduction (Wooldridge *et al.*, 2006).

The ASF virus can also be carried on arriving passenger clothing or footwear that contact pigs in the source country. Currently, passenger declarations require people to report if they have been on a farm or wild areas in the past 30 days, and any equipment still with them is cleaned and disinfected. However, interviews found not all products were being cleaned and disinfected upon arrival. The virus can persist for several days on fomites, particularly if protected by organic matter (Bellini *et al*., 2016). Therefore, anyone who had contact with an infected area, such as walkers, hunters or farmworkers visiting/returning to Tuvalu, could bring contaminated fomites into the country. According to the Aviation office, before the COVID-19 pandemic, approximately 7 000 passengers arrived in Tuvalu each year. There were three flights per week from Fiji, but transit passengers do not need to declare and clear customs there if the transit time is less than 10 hours (Fiji Airports, 2021). While data was not supplied, interviewees reported that a relatively small proportion of passengers came from regions where ASF is currently endemic. Therefore, there is a non-negligible likelihood that visitors could carry infected pork products or contaminated fomites into Tuvalu.

International waste on ships and planes is another important pathway of ASF introduction (Costard *et al*., 2009). Given all flights into Tuvalu pre-COVID originated in Fiji, food waste from planes should not be a pathway for introduction as long as the food for the flight came from Fiji, a country currently free of ASF. The waste from ships, however, remains a possible pathway. International commercial ships dock at Tuvalu's main port with cargo and fishing vessels. Crews and passengers may carry and not declare pork products; containers may be contaminated with the virus, and catering waste may contain contaminated pig meat. According to the Marine office, before the COVID-19 pandemic, approximately 20 commercial ships from Singapore arrived each year, but waste disposal was not allowed.

In conclusion, the likelihood of ASF virus entry through arrival passengers is non-negligible. It was impossible to quantify the risk because quantitative data about pork meat and products (i.e. type of products, volume) from arriving passengers were unavailable. Interviews with Quarantine indicated pork products were detected a couple of times per month from arrival passengers before COVID-19 travel restrictions. However, the product was typically allowed into the country as no biosecurity guidelines had been provided to highlight these products as risky.

4.3 EXPOSURE ASSESSMENT

Pigs could be exposed to ASF virus via feeding of leftover pork meat products or through contact with contaminated fomites from ASF affected countries. Swill feeding to pigs is a common practice in Tuvalu and is the most likely pathway for ASF virus exposure (Figure 7). Food waste from households could contain infected pork meat or have been contaminated by juice from infected pork. Although some pig farmers may cook waste materials before feeding them to pigs, it is difficult to ensure that the traditional cooking over an open fire is sufficient to inactivate the virus. Thermal inactivation at a core temperature of 70°C for a minimum of 30 minutes is required to destroy ASF virus (FAO, 2017).

Figure 7. Example of food scraps feeding on a pig farm in Tuvalu, ©FAO

Feral pigs may play a key role in ASF virus exposure. While the numbers of feral pigs appear to be low, they still pose a risk for exposure. Specifically, feral pigs may scavenge through food waste disposal that contains scraps of infected pork meat or have been contaminated by juice from infected pork.

Accordingly, the likelihood of ASF virus exposure is non-negligible.

4.4 CONSEQUENCE ASSESSMENT

The spread of ASF virus in the pig population depends on the speed of transmission and its economic impact. Once established, ASF virus spreads rapidly among pig populations. Pig holders in Tuvalu generally have no or low biosecurity. Low biosecurity is recognized as a risk factor for ASF (Sanchez-Vizcaino *et al*., 2013). Lack of basic biosecurity enhances virus spreading due to pig-to-pig contact opportunities. In addition, feral pigs are known to be a risk factor for ASF maintenance (Mur *et al*., 2016) as these animals are at high risk of contact with household food waste and wild pigs.

Inadequate home slaughter facilities sewage and waste disposal could be potential infection sources. The guts and trim wastes were normally buried, composted or dumped at the seaside. They could be directly accessible by feral pigs. Due to ASF being currently absent from Tuvalu, farmers are entirely unaware of the disease and its transmission mechanisms. Lack of awareness is therefore facilitating the free spread of the virus. It is unlikely that a disease outbreak will be promptly reported to DOA if farmers are unaware of it. Moreover, vehicles for the transport of pigs, pig feed and equipment may be shared.

The domestic pig population of Tuvalu consists of approximately 11 000 animals reared on 1 200 properties, mostly backyard piggeries (Tuvalu Central Statistics Division, 2021). Pigs are an integral component of Tuvaluan agriculture. They have cultural values by providing food security, high-quality protein nutrition and financial assets. They are also a financial asset as a reserve for cash requirements or festive seasons. The socioeconomic consequences of introducing and establishing ASF for the Tuvalu pig sector must be regarded as very high. In the event of an ASF outbreak, the rapid slaughter of pigs and proper disposal of pig carcasses are required to control the disease (OIE, 2019). The mortality and mass culling could lead to a substantial reduction in pig numbers which would cause significant socioeconomic losses threatens food security, culture and livelihood in Tuvalu.

In conclusion, the socioeconomic consequences of an ASF virus introduction were assessed to be very high, thus non-negligible.

4.5 OVERALL RISK ESTIMATION

The likelihood for an ASF virus introduction and its exposure were both regarded to be non-negligible. The consequences in terms of ASF virus spread and its economic impact are considered to be very high and non-negligible. Therefore, ASF is considered to pose a risk to Tuvalu.

5. Recommendations

5.1 REDUCING THE LIKELIHOOD OF ASF ENTRY

The main pathways for entry of ASF virus are via pork products. The less likely but non-negligible pathway was through contaminated fomites (boots, gears). These could enter via cargo, package and passenger's luggage. To reduce the likelihood of entry, we recommend:

- Passengers should be instructed to declare food products or contaminated fomites that can carry ASF virus or whether they have visited any farms recently (30 days) to the quarantine officer. Passengers can dispose of their food items in designated bins. Non-compliance shall be penalized.
- Promotional material should be clearly visible in arrival halls and at baggage carousels of airports to increase awareness of incoming passengers about pork products that can carry ASF and the importance of ASF to Tuvalu.
- Ensure the practice of disposing confiscated products in high-temperature incinerators.
- Increase awareness and provide training on ASF prevention including the importance of biosecurity measures and penalties for non-compliance to relevant stakeholders (Farmers, businesses, the general public, Quarantine, Custom, Aviation and Marine).
- Strengthen quarantine procedures and infrastructure to ensure that all baggages are manually searched thoroughly upon arrival. Installation and application of X-ray baggage scanner are recommended.

5.2 REDUCING THE LIKELIHOOD OF ASF EXPOSURE

From risk analysis, Tuvaluan pigs would primarily be exposed to ASF virus by feeding infected meat waste materials by pig farmers. The consultants recommend a public awareness campaign to encourage households to separate meat from vegetable waste and ban the supply of meat waste especially pork meat to pigs. Before feeding, the food waste should be thoroughly cooked to reach the core temperature of 70°C for 30 minutes.

5.3 REDUCING THE SIZE OF AN OUTBREAK

In the event of an ASF outbreak, the key to preventing further spread is early detection. Effective prevention requires a monitoring and surveillance system, facilitating early detection and timely intervention. Sufficient budget and personnel resources need to be allocated to motivate early reporting, implement active disease investigation and control, and organize access to laboratories capable of diagnosing ASF. DOA should provide information for veterinary paraprofessionals and livestock owners to recognize ASF and report promptly. Pig farmers and villagers should be aware of the dangers and negative impact of ASF to report unusual sick or dead pigs to veterinarians as soon as possible. DOA may also want to raise awareness about ASF through social media, TV, radio, printed materials, posters and meetings with farmers, animal traders, and the general public.

Once infected with ASF, all animals on the infected property, whether affected or unaffected, must be destroyed and disposed of correctly to prevent further spread. DOA needs to train, equip and deploy sufficient personnel for rapid culling and carcass disposal and cleaning and disinfection in the event of an outbreak. The ministry should develop a compensation strategy and allocate financial resources to ensure adequate compensation for the removal and disposal of affected pig herds as part of disease control measures to motivate compliance by pig owners.

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Annex 1. Questionnaires and data items

Following data items are submitted in electronic format

1. ASF Import Risk Assessment Questionnaires;
2. GEMP questionnaire completed by DRD;
3. ESRI shapefile of the Federated States of Micronesia administrative division (GADM);
4. ESRI shapefile of the Federated States of Micronesia OpenStreetMap (OSM) data.

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