AMBAE VOLCANIC ERUPTION

Food Security and Agricultural Livelihoods (FSAL) Needs assessment

December 2017
Acknowledgements

This assessment was conducted by the Risk and Resilience Unit (RRU) for the Food Security and Agriculture Cluster, thanks to contributions from the Directorates of Agriculture, Livestock and Fisheries from the Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB). It was made possible thanks to the hard work of the Provincial staff from Ambae, Santo and Tanna who conducted the field work and provided their technical expertise.

The National Disaster Management Office (NDMO), the Department of Water, Geology of Mines from the Ministry of Land and Natural Resources, as well as the Department of Meteorology and Geohazards also provided precious technical inputs.

The Food and Agriculture Organization of the United Nations (FAO) provided support through the deployment of a Needs Assessment Specialist upon request from the Government.

Sincere thanks go to the people of Ambae who dedicated their time and shared their perspectives and hardships with us.

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Cover picture: ash plume raising from Ambae volcano during the assessment data collection, taken from the North (credit: Lawrence Nimoho)

All pictures included in this report, unless stated otherwise, have been taken by members of the assessment team.
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EXECUTIVE SUMMARY

The Manaro-Voui volcano on Ambae island is considered by some volcanologists to be the most potentially dangerous volcano of the Vanuatu archipelago. The last deadly eruptions were 300 and 120 years ago, but regular activity was registered over the past decade. When activity increased in September, the Government decided to evacuate the entire population to neighboring islands where they were hosted for a month. End of November, around three weeks after the repatriation of Ambae residents, a needs assessment was conducted by the Food Security and Agriculture Cluster (FSAC), with staff from the Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB) and with support from the Food and Agriculture Organization of the United Nations (FAO), to provide detailed data of the damages and losses suffered by farming households both due to the direct impacts of the volcanic eruption (ashfall and acid rains) and indirect impacts during the evacuation (caused by animals and livestock), in the context of a dry season particularly pronounced in the West. This report presents the results of the assessment and proposes some options for recovery, depending on the evolution of volcanic activity.

Data collected through household interviews, completed by key informant interviews and technical expertise from the assessment team, shows that the entire population of the island was affected by the eruption, either directly or indirectly, and to different degrees. The disaster impacted Ambae residents in different ways:

Displacement affects some households who either moved towards the coastal areas, or left the island. Many households also have members who did not return.

Vegetable, root and cash crops were severely impacted, especially in the West and South where around 80% of respondents reported significant or severe damages. Several ashfall and acid rains events occurred since the repatriation, while loose animals were still damaging gardens in areas less affected by the volcano.

Livestock ownership was reduced, either due to predation during the evacuation, or to animals that were not recovered since the repatriation. Poultry numbers were particularly reduced. Surviving animals did not require any veterinary assistance, but the lack of feed and water is a severe concern in particular in the West and South where pastures were burnt by ashfall and acid rain.

Coastal fishing decreased significantly, with 50% of respondents not fishing anymore, and 30% fishing less, due to fear for their safety or
concerns about toxicity of the fish. **Tilapia ponds** were also affected, either damaged in their structure by livestock seeking water during the evacuation, or intoxicated by ashfall and acid rains that killed the fish.

**Forest plantations** also suffered damages, in particular in the West where trees burnt by acid rains shed their leaves, while animals caused damages to young trees in areas less affected by the volcano.

**Livelihoods and income**, which are mainly agriculture-based for the great majority of Ambae residents, have been consequently severely affected, with 30% earning no more income, and 65% earning less. Damages to cash crops that provided income to 85% of respondents before the eruption (in particular kava) will severely reduce income for years. Income losses were also

**Food security** is of high concern, in a context of subsistence farming. Nearly all respondents reported decreased food production, with up to 20% of respondents in the West not being able to produce any food anymore. The two main food markets, in the East (Saratamata) and West (Nduindui) are not functioning properly due to lack of supply, due to lack of local production in particular in the West, and also reticence from farmers to sell their products in the North and East. Food consumption has therefore deteriorated, both in quantity with 80% respondents using some food coping mechanisms, and in quality with 40% respondents having currently no access to fruit and vegetables nor to meat. Respondents are very concerned about the future, as more than 50% of households estimate they do not have enough to eat for more than a month, and up to 80% in the West.

This disaster is made particularly complex by the impossibility to predict the evolution of the volcanic activity. **Recommendations for the rehabilitation of the different sectors** are proposed at the end of this report, based on an intermediate scenario, but still valid with some adjustments for other possible evolutions of the volcanic activity on Ambae.
VOLCANIC ACTIVITY ON AMBAE

Volcano profile and history

Aoba, also known as Ambae, is a massive 2500 cu km basaltic shield volcano that is the most voluminous volcano of the New Hebrides archipelago. A pronounced NE-SW-trending rift zone dotted with scoria cones gives the 16 x 38 km island an elongated form. A broad pyroclastic cone containing three crater lakes is located at the summit of the Hawaiian-style shield volcano within the youngest of at least two nested calderas, the largest of which is 6 km in diameter. Post-caldera explosive eruptions formed the summit craters of Lake Voui and Lake Manaro Ngoru about 360 years ago. A tuff cone was constructed within Lake Voui about 60 years later. The latest known flank eruption, about 300 years ago, destroyed the population of the Nduindui area near the western coast. Possible eruption-related lahars or mudflows annihilated villages on the SE flanks of the island about 120 years ago, producing several casualties¹.

Ambae is considered by some volcanologists² to be the most potentially dangerous volcano of the Vanuatu archipelago because of the wide distribution of very young deposits related to strong explosive eruptions. They also cite thick lahar deposits, the presence of Lake Voui, long repose periods (about 300-400 years), strong degassing at the lake in 1991, and thousands of people living within 10 km of the crater.

The volcano is commonly called Manaro-Vui from the names of the two lakes set in the crater.

Recent volcanic activity

The most recent significant eruption in Ambae took place in 2005, with emission of ash and gas. About 5,000 people found shelter in least affected areas of the island on the Est and West tips more distant to the volcano. The volcanic activity stabilized and residents were able to return to their homes within three months.

The activity was low in the following years, with some degassing events in 2011 and 2013, until early September 2017, when a minor eruption started and the alert level was raised to 3 (on a scale of 0 to 4) by the National Disaster Management Office (NDMO).

At the end of September, the level was raised to 4, the volcanic activity increased with the emission of ash and the formation of lava fountains in the vent. About 8,000 people were then displaced from North and South to East and West tips of the island.

² Robin and Monzier (1993, 1994)
³ Photo by Karoly Nemeth, 2005 (Massey University).

Figure 2: The two lakes lying within the summit caldera of Ambae volcano, lake Voui (light blue) and lake Manaro (dark blue), and Pentecost island in the background.
Within a few days by October 4th, the Government organized the evacuation of the entire population of the island, 11,600 people, to the neighboring islands of Santo, Maewo and Pentecost.

On October 6th, the Alert level was lowered to 3. The State of emergency was extended until end of October.

After around one month spent in evacuation centers on neighboring islands, within three days around October 30, the Government organized the repatriation of all residents to Ambae island.

After the return of residents, ashfall events occurred throughout November, carried by the winds mainly to the West and South, to a lesser extent to the North and to the inland part of the East. Acid rains were reported by residents to the assessment team to have occurred on November 11th and 20th, particularly damaging in the West.

Early December, after data was collected, the alert level was downgraded from 3 to 2 and ash emission seemed to have reduced in December.

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4 Photo by Philipson Bani, 2005 (Institut Recherche Développement, IRD).
IMPACTS OF VOLCANIC ASH ON AGRICULTURE – A LITERATURE REVIEW

Volcanic ash characteristics

Volcanic ash is formed during explosive volcanic eruptions. Explosive eruptions occur when gases dissolved in molten rock (magma) expand as the magma rises, and then escape violently into the air, or when water is heated by magma and abruptly flashes into steam. The force of the escaping, expanding gas violently shatters solid rocks and shreds the magma blasting it into the air. Once airborne, the magma solidifies into fragments of volcanic rock and glass. Wind can then blow the tiny ash particles tens to thousands of kilometers away from the volcano.

Volcanic ash is not the product of combustion, like the soft fluffy material created by burning wood, leaves, or paper, but rather consists of fragments of rocks, minerals, and volcanic glass ranging in size from sand to clay-like (from 2 mm to less than 0.004 mm in diameter). Ash is hard, abrasive, mildly corrosive, conducts electricity when wet, and does not dissolve in water. Ash is spread over broad areas by wind.

Volcanoes emit gases during eruptions. Even when a volcano is not erupting, cracks in the ground allow gases to reach the surface through small openings called fumaroles. More than 90% of all gas emitted by volcanoes is water vapor (steam), most of which is heated ground water (underground water from rainfall and streams). Other common volcanic gases are carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine. Sulfur dioxide gas can react with water droplets in the atmosphere to create acid rain, which causes corrosion and harms vegetation. Carbon dioxide is heavier than air and can be trapped in low areas in concentrations that are deadly to people and animals. Fluorine, which in high concentrations is toxic, can be adsorbed onto volcanic ash particles that later fall to the ground.

The amount of available aerosols varies greatly between eruptions of similar size and volume5.

![Figure 5: Volcanic hazards](https://sites.google.com/a/k12.shorelineschools.org/lahar/home/general-information)

Chemical effects of ash and acid rains

The chemical effects of the ash would depend on the ash characteristics, particularly acidity (pH), and any reactive chemicals. An acidic ash of say pH less than 3 will cause burning of plant tissue. On leaves, this will have a similar effect to defoliation especially with dew or light rain,


6 Source: [https://sites.google.com/a/k12.shorelineschools.org/lahar/home/general-information](https://sites.google.com/a/k12.shorelineschools.org/lahar/home/general-information)
and may cause defoliation or even burning of leaf buds which would start to kill the plant. On fruit, acid may cause russet, delayed maturity, fruit drop, or impeded colour development.

Rainfall interacting with volcanic gas within the ash plume may produce acids that fall as acid rain. Continued degassing at the vent may lead to ongoing acid rain even after ashfall ceases. Acid raining falling on plants can lead to both issues for the plant surface, causing defoliation and plant death depending on how acid and how prolonged the acid rain was, but also hydration issues if absorbed through the soils.

Specific chemicals may be an issue for plants. Many plants are especially sensitive to volcanic gases such as fluorine. Root uptake of chemicals is regulated by the plant to some degree so would be less damaging than if significant quantities of gas were released into the air around sensitive plants.

Ash deposited on the ground can also cause also alter soil chemistry, altering the acidity, nutrient content and water content. Changes to these can all detriment the crop survival.

Complex effects of ash on agriculture

There is limited information on the effects of ashfall on agriculture and possible mitigation measures, and in particular in tropical climates, both due to limited research in this field, and due to a lack of detailed accounts of the effects of ashfall, including the ways that farmers and governments have attempted to reduce the damaging consequences to their crops and livestock.

Ashfall can have serious detrimental effects on agricultural crops and livestock depending mainly on ash thickness, the type and growing condition of a crop, the presence of soluble fluoride on the ash, timing and intensity of subsequent rainfall, condition of pasture and animals prior to ashfall, and availability of uncontaminated feed and water.

Volcanic ash can be damaging to humans, animals, the environment, infrastructure as well as agriculture. Some of the agricultural impacts are listed as below:

- Partial burial of plants leading to crop failure;
- Contamination of pasture making it unpalatable and leading to insufficient feed for livestock;
- Contamination of water supplies (for drinking and irrigation);
- Impacts to health of livestock feeding on ash-affected pasture (eye and respiratory irritation, grinding of teeth, fluorosis);
- Corrosion and wear-and-tear of the machinery including irrigation pumps
- Degradation in the quality of animal product (wool, leather, dairy product)
- Disruption of electricity supplies, transportation and modes of communication.

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7 Sarajavan 2017.
8 Picture: USGS, from Geology.com https://geology.com/articles/volcanic-ash.shtml
9 Source: USGS and Sarajavan 2017.
Crops

Impacts to arable crops are dependent on the type of crop, development stage of the crop, time of the year of eruption, duration of eruption, and climate.

Ashfall can have significant impacts on crops much like pasture land. Physical impacts from additional weight of ash on leaves, partial burial and stem/branch snapping all prevent the plants natural processes such as photosynthesis, transpiration and water content leading to crop failure.\(^\text{10}\)

As we saw acid raining falling on plants can lead to both issues for the plant surface with defoliation, burning of leaf buds and fruit drops, but also hydration issues if absorbed through the soils.

Ash deposited on the ground can also cause also alter soil chemistry, altering the acidity, nutrient content and water content, that can all detriment the crop survival.\(^\text{11}\)

Livestock

Livestock face risk from both falling and deposited volcanic ash. They are susceptible to a wide variety issues, predominantly from water and feed supply shortages leading to livestock dehydration and starvation.

Other issues include health concerns such as inhalation and respiratory discomfort, eye and skin irritation, abrasion of the teeth and hooves, ingestion leading to gastrointestinal blockages, and fluorosis. Fluorine poisoning and death can occur in livestock that graze on ash-covered grass if fluoride is present in high concentrations; it may be advisable to sample

and analyze ash or ash-coated vegetation to determine whether this potential hazard exists for livestock in areas covered with ash, even as thin as 1 mm.

\[\text{Lava Flows}\]

\[\text{Lava is molten rock (magma) that pours out or oozes onto the Earth's surface.}\]

\[\text{Pyroclastic Flows}\]

\[\text{Pyroclastic flows are hot avalanches of lava fragments and volcanic gas formed by the collapse of lava flows or eruption clouds.}\]

\[\text{Tephra}\]

\[\text{Explosive eruptions blast fragments of rock high into the air. Large fragments fall to the ground close to the volcano. Small fragments (called ash) from the largest eruptions can travel hundreds of miles.}\]

\[\text{Lahars}\]

\[\text{Lahars are fast-moving slurries of rock, mud and water that look and behave like flowing wet concrete. Landslides can transform into lahars. Pyroclastic flows can generate lahars by melting snow and ice.}\]

\[\text{Figure 7: Volcanic eruption products}\]

All these issues can occur with minimal ash coverage levels. There is a greater impact on soil grazing livestock such as sheep and deer.


\(^\text{12}\) Source:

compared to that of higher grazing animals such as cows. These effects each depend on:

- Ash characteristics (grainsize, composition, presence of poisonous aerosols)
- Rainfall and windfall before and after ashfall (to aid in the removal of ash from food source).
- Species and age of the livestock
- Nutritional demands of the livestock at the time of ashfall
- Pasture length
- Stocking rate\(^\text{13}\).

Depending on the quantity and toxicity of ash, livestock might require supplementary feed and clean water, or even to be evacuated.

Soils

Volcanic ash fall strongly affects agricultural areas downwind of volcanoes by smothering plants, changing drainage and soil infiltration, as well as chemically contaminating waterways and soils. Research to date on volcanic ash impacts on agriculture has been limited to direct impacts of ash on crops and livestocks, and little information is available on remediating the ash-affected soil.

In the long term (decades to centuries), addition of volcanic material can have positive effects on drainage, aeration, fertility and water retention. Short term impacts of ash fall however are, apart from the addition of some beneficial nutrients such as sulphur, likely to be negative.

Fresh tephra has very few plant-growth nutrients and no organic material. Apart from the addition of some beneficial nutrients such as sulphur, short-term impacts of ash fall are likely to be negative. Furthermore, many tephras are associated with acid aerosols adhering to the particles, which may hinder the germination of seeds.

The long-term damage to agricultural systems by volcanic ash is in many ways determined by its thickness. A thin coating of ash can be washed away by rain. Ash falls of up to 10 cm or so could be quickly remediated by ploughing. With thicker ash falls, the remediation actions are more complex\(^\text{14}\).

Depending on the physical and chemical effects of ash on agriculture, different options can be considered to rehabilitate farming and pasture land\(^\text{15}\):

i) **Rainfall / Irrigation:** In the case of slight ash fall, rainfall can suffice to wash the ash away. Depending on the season, irrigating the ash-affected soil to wash away the ash settled on soil is also used in some contexts as a recovery option.

ii) **Liming:** Considering the acidic nature of volcanic ash, liming can help neutralise the ash pH and bring back the affected soil to its original pH to function better.

iii) **Organic fertilization:** Volcanic ash causes a loss of soil fertility, therefore an addition of organic fertilization to the soil can help increase the level of organic nutrients and the number and growth of worms in the soil to mitigate this effect. Compost, vermi-compost, animal manure and green water from fish ponds can be used as fertilisers. Adding crop residues to the soils also increases carbon content and controls soil erosion.

iv) **Ploughing:** Depending on the thickness of ash on the soils, ploughing the top soil and mixing the ash with soil may reduce the impacts of ash and avoid the formation of a soil crust layer, hampering water infiltration and air exchange.

\(^{13}\) USGS

\(^{14}\) Saravajan et al., 2017.

\(^{15}\) Sarajavan 2017.
v) **Grass Mix:** Using different grass mixes can also be useful in order to recover the ash-affected soil (lupins, lotus, ryegrass, clover and chicory or others depending on the climate).

vi) **Biochar:** Biochar application can be a sustainable biological way to improve highly degraded lands. Biochar is a soil conditioner that enhances plant growth by supplying and retaining nutrients and by providing other services such as improving the physical, chemical and biological properties of the soil. Furthermore, Biochar influences the porosity and consistency through changing the bulk surface area, the pore size distribution, the particle size distribution and the density and packing.
OBJECTIVES AND METHODOLOGY

Objectives

Following the repatriation of the people of Ambae in October 2017, the Vanuatu Food Security and Agriculture Cluster (FSAC) conducted a Rapid assessment between November 1 and 3 to provide a quick picture of the situation of gardens, livestock and tilapia ponds affected by a combination of factors including the evacuation of the population leaving farms unattended, the ash fall, and the dry conditions. Results indicate that while food was still available, livestock had been significantly affected, as well as crops and fish ponds to different levels. The Southern part of the island, which is under predominant winds and was thought to be the most affected by ash fall, was however not covered by that assessment due to logistical constraints.

The FSAC met on 8th November to discuss these findings and recommended to conduct a Needs assessment to provide a detailed picture of the nature, magnitude and severity of the impact of the disaster; in addition to crops, livestock and fishing, to assess the impact on livelihoods and food security; to identify the needs of population and provide recommendations for recovery; to cover the entire island and provide data disaggregated at Area Council level (North, East, West and South) in order to identify differences in impact and needs.

Methodology and data collection process

The data collection took place from November 21 to 27. Data was collected at household level using a structured questionnaire with the Kobo Toolbox software in order to provide statistically representative data at the Council area level: West, North, East, and South. The sample was based on a 95% confidence level with 8 to 11% confidence interval at Area Council level, and 5% at the level of the island. Villages were selected using the cluster simple random sampling method, with corrections to ensure that broad areas were covered.

Household interviews were complemented by a light market survey on the main markets or shops of the island using Key Informant Interviews with Market chiefs as well as observations from the technical officers composing each team. In addition, enumerators took numerous pictures of the conditions of gardens, livestock, fish ponds and forests, as included in this report, to support what was reported by respondents to the household survey.
The household sample for each area was as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of households interviewed</th>
<th>Total households population</th>
<th>Proportion of population interviewed</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>56</td>
<td>388</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>North</td>
<td>69</td>
<td>656</td>
<td>11%</td>
<td>9%</td>
</tr>
<tr>
<td>South</td>
<td>72</td>
<td>266</td>
<td>27%</td>
<td>8%</td>
</tr>
<tr>
<td>West</td>
<td>45</td>
<td>688</td>
<td>7%</td>
<td>11%</td>
</tr>
<tr>
<td>Total Ambae</td>
<td>242</td>
<td>1998</td>
<td>12%</td>
<td>5%</td>
</tr>
</tbody>
</table>

The locations of households interviewed are shown on the map below.

The assessment team was composed of 12 technical officers from the MALLFFB with expertise in crops, livestock and fisheries, including the Ambae provincial staff and other officers coming from Port Vila, Santo and Tanna, plus the FAO Needs assessment consultant. The enumerators were organized in three teams, one team covering the West while the other two teams covered the North, South and East. See the list of enumerators in Annex 2.

Phone numbers of all respondents owning a phone were noted, in order to be able to monitor the evolution of the situation remotely through light phone-based interviews with the same households.
DEMOGRAPHY

Changes in household composition

The proportion of households headed by women remains unchanged after the repatriation, around 10% overall on Ambae.

However nearly a third of households interviewed reported that some members had not returned after the evacuation. This proportion is as high as 60% in the West (see graph below).

These persons who did not come back are mainly children (as reported by 45% of these households), left with relatives on other islands especially for the holiday season, but also men and women, while the proportion of elders was very marginal. The main reasons these persons did not return was the fear of the volcano, but also the need for the men and women to seek for income on other islands.

Housing and displacement

The proportion of households that were not living in their own house was around 5% overall, but as high as 20% in the West. These households were living in evacuation centers, i.e. churches and community buildings (see graph below).

By definition, the assessment cannot provide data on the proportion of households who have not returned to Ambae, but the assessment team did witness a number of empty houses, with neighbors reporting that the households had not returned or left again the island altogether. In some cases, it was reported that people had already bought new land and transferred to other islands. This situation raises concerns for these households who have to start a new life and new livelihoods elsewhere, but also for the households in Ambae who might need to leave but do not have the means to evacuate and purchase new land.
IMPACT ON CROPS

The importance of crop cultivation in Ambae

The Ambae population is essentially composed of subsistence farmers, with over 80% of households cultivating root, vegetable and cash crops before the eruption.

-over 80% of households cultivating root, vegetable and cash crops before the eruption.

Figure 13: Households cultivating different crops before the eruption.

Over 80% of households also made an income from the sale of cash crops overall, especially in the South and West, and 50% made an income from vegetable and fruit crops, especially in the West and North.

Crop cultivation is therefore important both to generate food for households’ own consumption, and for income generation.

Overview of damages to crops

Farming households were asked to report damages to their crops according to a classification in four categories:

1) severe damage (the plant died),
2) significant damage (the plant is burnt or shedding leaves but should recover),
3) moderate damage (the plant has been slightly affected but its survival is not threatened), and
4) no damage.

Figure 14: Ash plume raising from the volcano, seen from the West.

Damages reported according to this classification were very high, with over 60% of farming households overall in Ambae reporting severe or significant damage to their crops. Crop damages were reported to be the highest in the West with nearly 90% of respondents reporting severe or significant damages to some crop, and in the South (nearly 80%), against nearly 50% in the East and in the North, as per graph below. It was confirmed by the assessment that the West and South suffered more damages due to ashfall and acid rains, as we can see in the pictures.

Figure 15: Effects of acid rain on a palm tree in the inland East area council.
Vegetable crops appear to have been the most affected overall in Ambae, with over 80% respondents reporting severe or significant damage, as per the graph below.

**Figure 17: Damages to different crops by Area Council (sum of severe and significant damages).**

**Causes for crop losses**

The main reason reported for crop losses was the impact of volcanic ash and acid rain, for over 90% respondents, as per graph below.

However, the indirect impact of the eruption was also very high through the damages caused by animals set free during the evacuation, as reported by 60% people overall, but over 90% in the West.

The dry season was also an important cause of crop losses in the West which is the driest area of the island.
Geographic coverage of crop damages

The greatest magnitude, proportion and severity of damages to crops were found in the norther part of the West area council and throughout the South area council. The western part of the North and southern part of the East also reported significant damages. The eastern and western tips of the island received less ashfall, and mainly in the inland, while damages due to livestock seem to have been higher due to the density of population.

Therefore all areas were affected in a way, either due to the direct impact of the volcanic eruption itself with damages caused by ashfall and acid rains, or due to the indirect impact of the eruption with damages caused by livestock.

The maps below show the geographic location of damages reported to taro crops according to the four categories of the classification: severe, significant, moderate or no damage. Taro is taken as an illustration of damages as it is a key staple crop and largely cultivated by the population. As we saw, other crops such as kumala or vegetables suffered even higher damages.

21: Location of damages to taro crops by damage category from top to bottom: No damage, Moderate damage, Significant damage, and Severe damage (maps by Paul Worwor).
Damages to root and tuber crops

The assessment enquired about the four main root and tuber crops cultivated that provide the main staple food for the population: taro, manioc, kumala and yam. They have all been significantly affected, with kumala suffering the highest damages (over 70% of respondents report severe or significant damage), while manioc suffered (still nearly 50%).

Depending on the maturity of the crop, roots and tubers could still be harvested. Usually farmers were leaving the plants in the ground if they had been severely affected rather than harvesting them right away, especially as traditional preservation practices have been generally forgotten and lost.

Again, damages were the highest in the West and South, as we can see in the graphs below.

These reports on damages provided by respondents were corroborated by observations made by the assessment team, as we can see in the pictures below.
Damages to vegetable crops

As we saw, over 80% respondents cultivated vegetables before the eruption, however the variety of vegetable crops cultivated is limited, with island cabbage being by far the preferred vegetable crop both for its nutritional value and ease of cultivation, followed by tomato and beans to a lesser extent (see graph below).

Respondents were particularly worried about damages to island cabbage, which appears very sensitive to ashfall and acid rain, and commonly lost its leaves. This poses a nutritional concern as it is an important source of non-hem iron, in particular as access to iron from meat is already constrained. In some cases, people reported replacing island cabbage by taro leaves, going back to old traditions, although taro leaves do not have the same nutritional value.

Damages to vegetable crops were very high in all areas, but again, particularly in the South and West, as per graph below.

Figure 24: Garden with taro in good conditions in the East.

Figure 25: Burnt kumala plant in the West.

Figure 26: Damages to vegetable crops.

Figure 27: Kava plants completely burnt (upper picture) and partially burnt (picture above) in the West.
Damages to cash crops

Cash crops are the main source of income on Ambae, with 9% of respondents cultivating some cash crop, mainly kava, with cocoa and copra being also significant especially in the West, while vanilla cultivation is marginal (see graph below).

![Cash crops cultivated before the volcanic eruption](image1)

**Figure 28: Cash crops cultivated before the volcanic eruption.**

Damages to cash crops overall, mainly kava, were high, with over 50% respondents reporting severe or significant damage. This is slightly lower than damages to root and vegetable crops but still devastating in terms of income generation.

![Damages to CASH crops - kava and vanilla](image2)

**Figure 29: Damages to cash crops.**

Many kava farmers in most affected areas, in the West (80% reporting high damage), and in the South (nearly 70%) as per graph below, were harvesting their crops to sell it dry or fresh now and avoid losing their harvest. This means that after having received the price for this large sale, no more income can be expected from kava cultivation until at least three years if kava cuttings are replanted right away and not severely affected by the volcano.

![Kava roots harvested after damages caused by acid rain (upper picture) and dried for selling (above) in the West.](image3)

**Figure 30: Kava roots harvested after damages caused by acid rain (upper picture) and dried for selling (above) in the West.**

Crop perspectives

Less than 40% farmers have already replanted some annual crops since their return to Ambae, and only 25% in the South.

Crops replanted were mainly root crops, more than vegetable and kava. Overall 30% respondents had replanted some root crop, and only 10% had replanted vegetables, as per graph below.
The two main reasons given by respondents for not having yet replanted their crops were the fear of ashfall ruining their new crops, as well as general uncertainty about the future, including the possibility of having to evacuate again.

Respondents also raised concern about animals that had not been retrieved since the repatriation of residents and were still damaging their crops. The other possible reasons, lack of time, labour or tools, were very marginal.

Overall, concerns were particularly high in the West, as per graph below.

Around 80% of farmers affirm being willing to replant, with farmers in the West and South, more affected by the volcano, being slightly more reluctant. Therefore 20% are in grave incertitude or already considering moving, while the others express a desire to replant more than a decision.

Impact of ashfall and acid rains on crops differ according to the quantity of ash and vegetative stage of the plant, plants being particularly vulnerable in their early stages. Reluctance to replant is therefore understandable, but this situation raises a concern for food security, as root crops take a minimum of 6 to 8 months to reach maturity, and vegetable crops a minimum of three months. This means most people in Ambae will face a gap until they can next harvest any food or cash crop from their garden, as we will see in the food security section.
IMPACT ON LIVESTOCK

The importance of livestock rearing in Ambae

Almost all respondents, over 90% in all areas, had some animals before the eruption. Chicken was the most common animal, owned by 90% of respondents, followed by pig and cattle for around 50%. Goat ownership was marginal.

Less than 40% made an income from the sale of livestock, mainly in the West, but poultry was an important source of protein.

Animal losses

There was a reduction in the number of animals owned, but very few respondents reported losing all their animals altogether.

The main cause for animal losses was predation by dogs that were left alone on the island while people were evacuated. To feed themselves they attacked mostly chicken, and to a lesser extent pigs, goats, and calves. Some animals that were not set free when the island was evacuated, mostly cattle, also died of starvation.

The other cause of animal losses is that some animals that had been set free during the evacuation have not been retrieved. Now that the one month delay given to farmers to retrieve their animals following the repatriation has expired, there were reports of cattle being now killed by other farmers to protect their gardens.

It seems that chicken stocks, that suffered the most, are now increasing again.

Challenges for surviving animals

No problem was reported about sick or injured animals. However, nearly 60% of livestock owners reported not having enough feed or water for their animals, and up to 75% in the South and West.

33: Livestock ownership, as proportion of respondents reporting owning any of the different types of animals before the eruption.

34: Main causes for animal losses, as reported by farmers having lost animals.

35: Farmers reporting not having enough feed or water for their animals.
The main reason for the lack of feed was ashfall having affected pastures especially in the West and South, burning the grass. There is also a concern about the lack of water for animals, which is a chronic issue but aggravated by the fear of water being contaminated by ashfall and acid rains.

36: Difficulties with feed and water as reported by livestock owners.

In the West, the team observed cattle left to browse on banana trunks for feed and water. The team could also see a number of cattle that had been abandoned. Cattle owners in the South and West reported wanting to sell their animals even at below normal price, as they cannot feed them anymore.

However, in most of the North and on the eastern and eastern tips of the island, pastures are in very good conditions. Some fields, in particular copra plantations, were even overgrown as owners had lost their cattle.

37: Cattle left to feed on a banana plant in the West.

38: Burnt pasture in the West.

39: Burnt pasture in the South.

40: Cattle tethered and apparently abandoned with no feed nor water for days in the West.

41: Pastures in the western tip as here, as well as in the eastern tip of the island, are in good conditions.
IMPACT ON FISHERIES

Coastal fisheries

Over 40% of respondents were involved in coastal fishing before the eruption. It was most important in the West and South. It appears that fishermen in the West and North practice both reef and open sea fishing with canoes, while in the South fishing is mostly conducted in the reef, without canoe.

About 40% of respondents were also eating sea food. There is not a significant market for sea products in Ambae, but it still provides complimentary income for nearly 30% of respondents in the West and 20% in the North.

Overall, nearly 50% of households involved in fishing before the eruption reported they were not fishing anymore, and nearly 30% reported they were fishing less. The main reasons were the fear for fish to be toxic, as creeks are carrying ash from the slopes of the volcano into the sea, or possibly because of concerns for ciguatera if the coral is affected by ashfall into the sea. Other reasons advanced were the fear of tsunamis, and a lower number of fish in the reef. Respondents reported being willing to go back to fishing, once provided with necessary information on safety.

This decrease in fishing is a concern, mainly as protein intake has already been reduced since the eruption due to livestock losses.

The reduction in fishing was the most important in the South, possibly as people only fish in the reef, which was reported to have been affected by ash running down the creeks.

The freshwater streams on Ambae have indeed been contaminated by ash, with the water turning muddy, and causing the death of freshwater fish, prawns and eels then carried into the sea, as it was witnessed by the assessment team. It is unlikely that the ash carried by the creeks would create damage to the reef fish, but this would need to be checked and verified, in order to inform fishermen and encourage them to go back to fishing.
Tilapia ponds

There are around 40 fish ponds in Ambae, set by the Ministry in the past few years. These are small rain fed ponds (around 2 by 4 meters and 60 cm deep), using fish pond liner as the volcanic soil is too porous. The tilapia fish are easy to raise and breed, feeding on algae and vegetarian diet. They reach maturity in four months and provide a good source of protein. Green water from the ponds is also used as a free and quality fertiliser for vegetable farming, following the integrated farming approach jointly demonstrated and strongly encouraged by DARD and Fisheries Department, although this practice still needs to be more widely adopted by farmers.

Fish ponds were affected in two ways. Farmers first reported damages to their ponds due to livestock degrading the plastic linen while trying to access water while the island was evacuated. Following the acid rains in November, farmers also reported that their fish died, as tilapia are sensitive to the acidity of the water.

Most of the damages caused by ashfall and acid rain to fish ponds were reported in the North and likely in the West, although more detailed information is needed. Tilapia ponds in the East were less affected by ashfall and therefore suffered minimal fish losses.

Taking opportunity of the participation of a fishery officer from Santo in the assessment, the Aquaculture section and DARD at Saratamata worked together to supply 600 tilapia fingerlings to some old and new tilapia backyard farms in the areas less affected by ashfall and acid rain.
IMPACT ON FORESTRY

Forest plantations

Over 40% of respondents were managing a tree plantation before the eruption, including timber trees, scented trees (sandal wood) and fruit and nut trees.

Forest plantations were affected by acid rains in the West, South and North. Livestock also caused significant damage to young trees, especially in the East where animals were more concentrated due to higher density of population.

In the West where the effects of acid rains were more severe, trees shed their leaves, as we can see with sandal trees in the picture below.

A small number of people, 7% overall, even reported losing their plantation altogether.

47: Bare sandal trees in the West, having shed their leaves due to acid rains.

The general vegetation was affected by ashfall and acid rains, with most trees shedding their leaves in areas most affected by ashfall and acid rains in the West. Vegetation was however affected to different degrees in a same area, indicating that some plants are much more sensitive than others.

48: Different degrees of damages caused by ashfall and acid rain on vegetation in the West, with coconut trees appearing less affected at this stage.

Fruit plants such as papaya and in particular banana plants were very sensitive to ashfall and acid rain. Ashfall and acid rains can have different effects on fruit trees, they can burn the leaves but also lead to the plant dropping its fruits, as it was the case for mango trees in the West. However, coconut, pandanus, natangura and navel trees as well as pineapple plants appear to be more resistant to ashfall and acid rain.

49: Papaya tree affected by ashfall and acid rain in the North.
These damages to forest therefore have an immediate impact for residents in terms of access to food from nuts and fruits, especially at a time when the quality and diversity of the diet is already constrained. But it will also have a longer-term impact on income generation, as it will take several years to replace trees that have died. There is also a larger impact on native vegetation, insects and microorganisms that live in it, and more broadly the ecosystem, which is difficult to apprehend yet.

50: Banana trees affected by ashfall and acid rain in the West.

51: Papaya plants affected by ashfall and acid rain in the South.

52: Detail of ash on vegetation in the South.

53: Healthy vegetation in the East.

54: Healthy vegetation in the West.
IMPLICATIONS FOR LIVELIHOODS AND INCOME

Livelihoods on Ambae before the eruption

Respondents were almost all involved in cash crops, vegetable and fruit crops cultivation and livestock rearing before the volcanic eruption. Around 40% were also involved in coastal fishing and timber plantation, only a few had fish ponds.

The main sources of income before the eruption were the sale of cash crops (85%), followed by the sale of food crops (50%) and livestock (40%).

It should also be noted that there are significant differences in households receiving remittances between the different areas of Ambae, with over 25% of households in the West receiving remittances, against about 5% in the North and East, and none in the South. This involves differences in the capacity of households to cope with the drop in income from agricultural activities in Ambae.
Changes in levels of income

Due to the impact of the volcanic eruption on agriculture-based livelihoods, income levels have dropped drastically: 30% report earning no income currently, and 65% report earning less than before.

![Changes in amount of income earned since the volcanic eruption](image1)

58: Changes in levels of income since the volcanic eruption.

Other factors besides the volcano itself have affected income. In the North where nearly 40% of households have lost their income, the assessment team found out that farmers had been informed not to market as the market in Saratamata was used for storing food aid. Once the distribution completed, the market became available for sales again, however a rumor had spread among farmers in the North and East that if they came to sell their products, they would not get any more food aid. There is an urgent need to inform farmers and correct this belief, as this is both causing a loss of income for farmers, and making access to fresh foods difficult for people who would need to rely from the market in this moment.

Livelihood and income: perspectives

It was reported that farmers are currently uprooting and selling kava, dry or fresh, to avoid losing their harvests. Therefore, current income is still benefiting from these sales.

However, future income will likely further decrease, as only around 15% of farmers have already replanted cash crops or vegetables. Even if farmers replanted right now, it would still take minimum 3 months to harvest any vegetable, and three years to harvest kava.

Remittances and connections will also likely play an important role in the next months for Ambae residents, providing a safety net to cope with the current economic constraints, and possibly better opportunities for the households having connections with relatives on other islands to find alternate income and livelihood activities, including by migrating out of Ambae.

![Farmer harvesting and processing all his kava crops in the West.](image2)

59: Farmer harvesting and processing all his kava crops in the West.
IMPLICATIONS FOR FOOD SECURITY AND NUTRITION

Access to food from production and aid

Households’ access to food from their own production has decreased due to the impact of the volcanic eruption on crops. Overall nearly 90% of respondents reported that their food production had decreased. Up to nearly 20% of people in the West even reported not getting any food from their gardens anymore.

![Changes in amounts of food produced by farmers.](image)

About 60% of respondents declared having received food aid since their return to Ambae, with differences between 75% in the East and 40% in the South, indicating inequalities in access to aid, either public or private. It is therefore important to ensure that communities in the South, although more isolated, are not unequally assisted.

A Government food distribution was planned to take place right after the assessment, providing food rations for all residents of the island for one month, in the form of rice, tin fish and noodles. The effect of the food distribution is therefore not visible in the data presented here, which allows to present the real situation without the temporary mitigating effect of food aid and to better identify the needs.

Access to food from markets and stores

Over 70% of respondents reported having currently access to a shop or market to purchase food, with lower access in the South (65%) and better in the West and East (85%). The main constraints reported in terms of food purchase economic with the high prices of food, but food availability on the markets was reported as a major issue in the West, as we will see.

![Constraints to purchase food.](image)

About 50% of households overall can purchase food on credit from a store, and over 20%
currently have a debt. While having access to food on credit is a positive factor for food access, around 25% of the households owing money do not think they will be able to pay back their debt – and it is particularly high in the North with 40%, highlighting the economic constraints and uncertainty about the future.

In the West, the market was also not functioning, as there is not enough local production to supply the market, and it is not supplied from other islands.

Food consumption and nutrition

Before the eruption, most consumed foods were root crops and cereals for nearly 90% HH, while 70% ate vegetables and fruits, 70% also ate meat, and 40% ate seafood.

Quantities of food eaten have been reduced for all groups, while some of the food consumption has shifted to cereals, likely reflecting he food aid provided with rice and noodles.

Dietary diversity has also deteriorated. Consumption of fruits and vegetable has reduced the most, while less than 70% of households were consuming any already before the eruption. As a result, nearly 40% of households do not having access to vegetables and fruits currently, and nearly the same
proportion does not consume any meat, while the others consume mostly less than before.

Food insecurity

About 20% of respondents reported having experienced hunger with no food to eat in their house since their repatriation a month before, rarely or sometimes, indicating difficulties to access food, in particular in the North.

About 80% also reported using at least one of the 5 food coping mechanisms, mainly limiting food portion size at meal time, but 25% used the more severe mechanism of restricting adult consumption for children to eat. These constraints are more widespread in the West and North.

This indicates that over 80% of households do already suffer from some level of food insecurity, and the situation is likely to deteriorate over the next months. When asked how long they thought they would be able to feed their families both from their own production and from food purchase, 55% did not think they could access enough food for more than one month.

Households in the East seem the less insecure with 60% estimating they could access food beyond two months, while households in the West are the most insecure, with nearly 80% reporting they would not be able to access food for more than a month, and including 50% not even able to reach one month.
PERSPECTIVES

Three possible scenarios

The main challenge of this disaster is the impossibility to forecast the activity of the volcano, and therefore to make any projection on what will happen in Ambae. The table below is therefore not a projection, nor a full-fledged scenario development exercise, but a humble support for reflection on different possible trajectories, by envisaging a best case and a worst-case scenario, and an intermediate scenario in between. The purpose is to look at what would be the needs, therefore it looks mainly at what would happen in the most affected areas. It points that a food gap can be expected for varying duration and proportion of residents and even in the best case scenario, and that relocation of some households might be indicated even in the likely scenario.

<table>
<thead>
<tr>
<th></th>
<th>BEST CASE SCENARIO: VOLCANIC ACTIVITY STOPS, NO MORE IMPACT FROM ASHFALL AND ACID RAIN</th>
<th>INTERMEDIATE SCENARIO: NO VOLCANIC ERUPTION BUT REPEATED EVENTS OF ASHFALL AND ACID RAINS</th>
<th>WORST CASE SCENARIO: INCREASING VOLCANIC ACTIVITY, INTENSE ASHFALL AND ACID RAIN, ERUPTION.</th>
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<tbody>
<tr>
<td>CROPS</td>
<td>It still takes a few weeks for farmers to replant root, vegetable and cash crops, as they are waiting for more information and to see if the volcano stabilizes. In the most affected areas where crops had died, it takes therefore nearly four months before the newly planted root or vegetable crops can be harvested.</td>
<td>It takes several weeks for most farmers to replant root, vegetable and cash crops in areas with moderate to significant exposure to ashfall and acid rain. Until tunnels or other solutions are provided, crops in these areas still suffer damages from these events, especially as they are the most vulnerable in the early stages, meaning future harvest are delayed and reduced. Farmers in the most exposed areas, as well as some farmers in other areas, either do not plant again or lose their crops.</td>
<td>People from most affected areas, most of the island excepted for the Eastern and Western ends, cannot cultivate crops on their land anymore.</td>
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<tr>
<td>LIVESTOCK</td>
<td>In the most affected areas, it takes likely several weeks before the pasture can recover, leading to some animal losses due to lack of feed.</td>
<td>Pasture land does not recover in most affected areas, and become insufficient in other areas exposed to ashfall. Farmers destock part of their animals, by selling them if they get appropriate support, or lose</td>
<td>Animals in affected areas are sold off if possible, or abandoned and die.</td>
</tr>
<tr>
<td><strong>FISHERIES</strong></td>
<td>Some animals if they cannot destock them.</td>
<td>Similarly, it takes a few weeks before people go back to fishing. Damaged fish ponds need to be repaired, other ponds can be replenished.</td>
<td>People are reluctant to go back to fishing until they get information and confirmation of non-toxicity, especially in the reef. Fish ponds in the most affected areas cannot be rehabilitated in the short term as they are too exposed to ashfall, while fish ponds in less exposed areas can be rehabilitated only with some innovative solutions.</td>
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<tr>
<td><strong>LIVELIHOODS</strong></td>
<td>Agricultural activities resume on all areas of the island, although in areas that have been the most affected there will be a gap in income until cash crops can be harvested again, meaning several years of hardship.</td>
<td>Some people in the most affected areas who have the means and/or the support needed leave the island, mainly in the West. People in most affected areas who do not have the opportunity to leave, in particular in the South, see their livelihoods and food access further deteriorate unless they can relocate.</td>
<td>People from most affected areas who have the means to leave resettle on other islands. People from inland and people from most affected coastal areas move to the coast in the less affected areas (extreme East and West), putting pressure on local resources and facilities. They lose access to their livelihood assets (land, house, business).</td>
</tr>
<tr>
<td><strong>FOOD SECURITY</strong></td>
<td>Likely food gap, short term food aid needed.</td>
<td>People in most affected areas might not be able to resume farming and produce their food. Food gap can be expected for a large portion of the population, further food aid needed, or food vouchers with farmers from neighboring islands.</td>
<td>Farmers in affected areas, having relocated to the safe areas, are unable to produce enough food and do not have the economic means to purchase enough food. Food aid is necessary.</td>
</tr>
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NEEDS AND RECOMMENDATIONS

A complex and protracted disaster

This disaster is particularly complex, first as it involves chemical and biological factors which cannot be observed and require rare expertise, second as there is little literature on the effects of ash on agriculture and mitigation options especially in tropical climates, and even little capitalization on the experience of people living with active volcanoes on other islands in Vanuatu, and finally as it depends on volcanic activity which cannot be forecasted.

In such difficult circumstances, as decisions still need to be made and some people are facing urgent needs, response and recovery options rely on a number of assumptions from the intermediate scenario presented before, but also offer viable options to be adjusted for the best and worst-case scenarios. These recommendations take into account the needs expressed by farmers themselves during the assessment, as well as technical expertise provided by the assessment team and FSAC, for the short and medium terms. Recovering will also mean adapting to new conditions, therefore there will be a need for trial, research and develop innovative solutions, which can benefit the people of Ambae but also people on other islands in Vanuatu who do or might have some day to live with an active volcano.

Recommendations are proposed for the different agriculture sectors and thematic areas:

- Technical Expertise
- Crops
- Livestock
- Fisheries
- Alternative income sources
- Food Security
- Training and Awareness
- Issues for other Clusters

Recommendations are summarized in the table below, and also explained in more details later, in particular for the more urgent and technical activities related to crops, livestock and fisheries.

<table>
<thead>
<tr>
<th>SECTOR/AREA</th>
<th>SHORT TERM (NEXT SIX MONTHS)</th>
<th>MEDIUM TERM (BEYOND SIX MONTHS)</th>
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| Technical Expertise | 1. Soil and ash analysis to be carried out on agricultural land in Ambae, both for gardens and pasture land, possibly with support from the South Pacific Community.  
                   | 2. Monitoring of the situation, by phone (using phone numbers of respondents of this assessment) and on the ground, in particular to assess needs for further food aid. | 3. Continuous monitoring |
| Crops             | 1. Depending on results of soil analysis, identify adequate practices to rehabilitate farming | 6. Learning from experimentation and willingness of farmers to |
soils. Teach these practices to farmers and provide inputs (lime) as required.
2. Establish food and cash crop and forestry nursery sites in tunnel houses in different areas of Ambae.
3. Explore options to harvest and neutralize rain water from acidity for use in garden
4. Experiment introducing resilient and early maturing crops, in particular from Tanna
5. Fencing materials to set gardens close to communities but protected from animals

**Livestock**

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<tr>
<td>1.</td>
<td>Increase poultry production thanks to a hatchery in the breeding centre</td>
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<td>2.</td>
<td>Introduce integrated poultry farming with backyard gardening in paddocks so eggs can be collected and gardens fertilized, by providing training and fencing material</td>
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<td>3.</td>
<td>In the extreme West and East where there is still good pasture, Government through DoL to liaise with land owners for the establishment of agistment paddocks and yards</td>
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<td>4.</td>
<td>Facilitate the sale of animals from farmers in most affected areas to areas least affected. Collect abandoned animals.</td>
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<td>5.</td>
<td>Operationalize the local butchery on Saratamata to support destocking in most affected areas.</td>
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<td>6.</td>
<td>Explore opportunity of mineral feed supplementation to help animals (mainly cattle) recover from stress.</td>
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**Fisheries**

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<tr>
<td>1.</td>
<td>Check the reef conditions and inform people about safety of fishing</td>
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<td>2.</td>
<td>Deploy FAD at Lolowai, Devils Rock and Saratamata</td>
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<td>3.</td>
<td>Review conditions of all fish ponds</td>
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<td>4.</td>
<td>Experiment tilapia fish ponds with transparent plastic linen as a protection from ashfall integrated with tunnel gardening in moderately affected areas</td>
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<tr>
<td>5.</td>
<td>Explore and experiment options to harvest and neutralize rain water for use in fish ponds</td>
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<tr>
<td>6.</td>
<td>Establish tilapia hatchery in Saratamata</td>
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**Livelihoods and Food Security**

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<td>1.</td>
<td>Provide food aid at least to the most affected areas, West, South, West North and South East</td>
</tr>
<tr>
<td>2.</td>
<td>Monitor further food needs</td>
</tr>
<tr>
<td>3.</td>
<td>Encourage market activity to resume where possible</td>
</tr>
</tbody>
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7. Train farmers on pasture management, possibly improve pasture in moderately affected areas
8. Provide fencing for livestock paddocks
9. Provide training on livestock management and welfare issues
10. Make sure all cattle have identification means for ease of movement to and from agistment paddocks. Such identification system must be recorded and kept somewhere for tracing purposes.

7. Assess and make necessary upgrades to the provincial fish market in accordance with the seafood safety standards.
8. Re-establish a canoe fishing program
9. Establish a mini fishing gear shop
10. Rehabilitate and set up over 40 tilapia fish ponds on Ambae

5. Possibly conduct a food voucher programme to provide food to people living in most affected areas (cf. in Tanna)
6. Support the development of alternative income
4. Encourage local food vendors from neighbouring islands and less affected areas to sell surplus to affected areas

7. Provide training on food preservation techniques

Training and Awareness

1. Conduct experience sharing workshops with farmers and rural population, inviting farmers from Tanna and Ambrym – possibly two workshops in each Council area
2. Provide training for activities as identified above: tunnel gardening, rainwater harvesting, integrated chicken farming in particular.
3. Conduct regular visits and technical support to communities through Ambae MALLFFB staff
4. Provide information and encourage farmers to resume activities and adapt as relevant, possibly through radio spots
5. In particular, conduct community awareness on coastal fishing

6. Conduct further trainings based on successful adaptation techniques (green houses, new crop varieties, integrated garden-tilapia ponds, rainwater harvesting, paddock chicken rearing...) as well as other activities identified above (livestock and pasture management, food preservation techniques, alternative income generation activities)

Issues for other Clusters

1. WASH cluster: High concerns raised by residents over the toxicity of water for human consumption, in particular with some people in the West reporting stomach ache
2. Health cluster: Serious concern with strong smell of sulfur in the air in the South and West, and people reporting irritations to throat, eyes, skin: risk of ARI, especially for infants and vulnerable populations
3. Education: Residents raised concerns about not being able to pay for school fees for the new year, and therefore not being able to send their children to school

4. Gender and protection: need to provide psychosocial support

Technical Expertise

The impact of ash on agricultural soil is complex, depending on the chemical composition of the ash, but also the structure and profile of the soil. There is a risk of soil acidity increasing on the effect of ash, but also of soil fertility to decrease and microbiological activity to be affected, as well as for possible chemical components such as Sulphur and fluorine of ash to contaminate the plants and those feeding on them, in particular livestock grazing on pasture covered in ash. There might even be a possibility that some land is not fit for agriculture anymore or would require specific rehabilitation measures, and this should be known before introducing possible recovery options for crops and livestock.

Such an assessment is therefore an exercise in its own, requiring a significant number of soil and ash samples taken to be representative, as
well as soil fertility analyses that cannot be conducted with a simple PH testing kit\textsuperscript{16}. It is recommended to enquire with the South Pacific Community on the possibility to get the support to conduct such an assessment.

If the situation protracts, it will be necessary to closely monitor the situation. A light monitoring can be conducted over the next weeks/few months by phone, using the phone numbers collected from the respondents to this present assessment, supported by visits from the provincial staff on Ambae. However if the situation protracts more than a few months, another field assessment might be necessary.

**Crops**

Before substantial efforts are invested to adapt cropping practices to the effects of the volcano, it should be ascertained from the ash and soil analysis that the soil conditions in the most affected areas are still favorable for crop cultivation. If frequent ashfall and acid rain events continue, some areas might also be too exposed to be used for agriculture, be it crop or pasture. Some solutions exist to grow crops out of soil in inert substrates through hydroponics, but it should be carefully considered whether these techniques are adapted to subsistence farming and can be easily taken up by farmers.

If ashfall and acid rain event cease, or in areas less exposed to such ongoing events, solutions exist to rehabilitate the soil depending on the quantity and chemical properties of the ash that fell. We already know, from the occurrence of acid rains, that the ash was acidic, but its effect on the soil needs to be determined. Lime can be used to correct the acidity as necessary, as well as organic fertilization, amendments and mulching to improve the soil structure, and practices such as mixing the ash deposits with the top soil, would likely be necessary to ensure good and prompt recovery of farming land (see the options in the *Impacts of volcanic ash on agriculture – a literature review* section). These practices would also have to be taught to farmers so they can keep implementing them over time (organic fertilization, compost, mulching).

If the ashfall continues over time, one possible solution to protect crops from ashfall and acid rains is the use of tunnels. It was reported that the use of tunnel was attempted in Tanna but failed due to the high humidity accumulating inside. In tropical climate, a specific type of tunnel with passive ventilation, as in the figure below, should be used to avoid such problem.


Such tunnels could be used as nurseries as well as to grow important crops. In a first stage, it would be recommended to use them as nurseries in less affected areas, to ensure that even in time of important ash emission affecting crops, seedlings (for vegetable, root and cash crops as well as trees) are available in the tunnel and ready to be transplanted immediately. To adapt to living with an active volcano, it is key to be able to replant promptly when such events occur. At the same time, tunnels can also be installed in moderately affected areas in each area council at


community level and/or with key farmers, in order to assess both the technical validity of the approach in a context of repeated ashfall, as well as willingness of communities to adopt it.

Water is a chronic issue on Ambae as farmers depend exclusively on rainwater for agriculture, meaning that water is scarce during the dry season. With the use of tunnels, it will be necessary to water the seedlings inside, which is a challenge. Underground water should be kept for human consumption as it is possibly the safest source of potable water, while rainwater, which would be the best option, risks to be contaminated by ash and acid rains. Since ash is not soluble in water, and tends to aggregate into muddy deposits on the bottom of water bodies, one option to be explored depending on the results of the ash chemical composition, would be the use of water settling ponds, where rainwater would be harvested including from the tunnel roof through gutters, and let to settle until ash deposits have fallen at the bottom. At that point the surface water can be used to irrigate. This system could be associated with the fish ponds in line with the integrated farming approach, the water from settling ponds being used to replenish the fish ponds, and the green water from the fish ponds being used to irrigate and fertilize the tunnel and crops. Issues related to acidity in the water could be addressed by using small quantities of lime, which are not harmful to tilapia fish. Feasibility of this option would first need to be confirmed by ash and soil analysis results, and then trialed at a small scale.

Another important activity will be to introduce new varieties of crops more resilient to ash as well as early maturing crops. It is recommended to introduce seedlings of crops grown on Tanna that have proven to cope better with volcanic conditions there, to see if they have the same results on Ambae, which needs to be confirmed as soils and volcanoes may have different characteristics.

Finally, the issue of livestock damaging gardens need to be addressed. One option would be to set fenced paddocks for livestock, however this would be a challenge for free range animals such as pigs, and feed in the paddocks might become insufficient for animals, while at the same time it would require an important quantity of fencing material. The other option recommended is to rather fence the gardens to protect them from livestock. This would allow farmers to set gardens closer to their homes, in particular for crops that require more care, and to ease their efforts to replanting crops damaged by ash.

Livestock

With the loss of animals during the evacuation, and in particular chicken that were the main source of protein for residents on Ambae, access to protein is now limited. Poultry restocking, which is slowly happening naturally, should be supported with a “building back better” perspective. Egg consumption is almost non-existent in Ambae as chicken are free-range. A good way to improve access to proteins is to make possible the collection of eggs by raising chicken in cages or fenced areas (paddocks). Raising chicken in cages is less resilient as it requires to provide complete feed to the chicken, which are themselves healthier and provide better quality products if they can access their natural and diverse diet by foraging freely. A preferred option would therefore be to raise chicken in paddocks, where pasture ground can be protected from over grazing by rotating the chicken through different paddocks, as presented in the graph below.
Even better, this system can be associated with crop cultivating in an integrated farming approach: one paddock is cultivated as garden, once crops are harvested chicken move into the paddock to benefit from crop residues, limit pest from spreading by eating insects, and fertilize and mix the soil, as per figure below. Depending on duration of crop cycles, there can be more than two paddocks to ensure adequate rotation of chicken for sustainable foraging.

Regarding livestock, it is urgent to move animals and in particular cattle from the most affected areas where pasture ground is burnt, therefore feed insufficient and possibly toxic for animals if the ash contains high levels of fluoride and Sulphur (to be confirmed by the ash and soil assessment).

There are three possible solutions for these animals:

i) they can be temporarily moved to some healthy pasture fields available in the extreme East and West of the island, where some animals could be transferred in agistment paddocks, following an agreement with land owners.

ii) they can be destocked by encouraging the sale of animals from owners in more affected areas to owners in least affected areas who lost their animals, or even possibly outside the island, helping farmers to get a fair price for their animals.

iii) they can be butchered, offering thus a source of protein for residents. This would require rehabilitating the butchery in Saratamata. This could be combine with the first solution, letting animals recover by grazing on healthy pasture for a while before butchering them.

If ashfall continues, it is likely that the number of livestock will have to be kept lower than it was before the eruption, as some pasture would become unavailable. Experience from other volcanic eruptions indicate that pasture recovery showed good results with the sowing of grass mixes (ryegrass, clover and chicory in New Zealand )20.

Depending on the ash toxicity and regularity of ashfall, it could be considered whether improving pastures in moderately or less affected areas by sowing perennial fodder crop varieties with better nutritional values and lower vulnerability to ash/better recovery capacities, could be a valid option to maintain

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access to feed for cattle in the new volcanic conditions.

**Fisheries**

In terms of sea fishing, respondents reported having suspended or decreased their fishing activities due to concerns about toxicity of fish in the reef. Although sea fish should not be affected by the volcanic activity, to the difference of fresh water fish in the creeks, the reef conditions should be checked to provide informed reassurance to residents about safety of reef and open sea fishing.

Fish Aggregating Devices (FAD), possibly three units, could be installed along the northern and eastern shores to make fishing of pelagic species more accessible. One device had been installed in recent years but was washed away during a cyclone. Residents are therefore familiar with the device and with canoe fishing, and limited technical and material support would be necessary.

![Fish Aggregating Device infographic (FAD)](https://www.fao.org/fileadmin/user_upload/newsroom/docs/FAD-infographic.pdf)

**Figure 74:** Fish Aggregating Device infographic (FAD)

In terms of inland fishing, a complete review of all fish ponds should be conducted to establish the number of tilapia ponds damaged in their structure and those whose fish died because of ash. Ponds damaged by animals in areas least affected by ash should be rehabilitated right away. As for damages related to ash, the approach should be similar to the one followed for crops, with the establishment of a hatchery in the least affected area such as Saratamata in order to have the fingerlings stocks available on the island to restock the ponds. Similarly to the approach followed for crops as well, it might not be worth investing efforts to rehabilitate ponds in the most affected areas that will be subject to repeated ashfalls. Rather, efforts could focus on moderately and less affected areas to explore the option of protected ponds, using a transparent plastic sheet to cover the ponds and protect them from ashfall and acid rain while letting through the light necessary to the algae photosynthesis on which the tilapia feed. This option could be associated with the tunnel gardening, as well as the rainwater neutralizing detailed in the crop section, since water is the limiting factor.

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Annex 1. References

Online resources
Vanuatu population data: Pop GIS 2.0 based on 2009 population census http://vanuatu.popgis.spc.int/#l=en;v=map4

Publications
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S. Cronin et al., Assessment and management of the environmental health hazard related to volcanic degassing in Vanuatu. http://www2.wpro.who.int/NR/rdonlyres/F5C922D3-497B-44C9-8F2C-96EBA86340FA/0/AssessmentandmanagementoftheenvironmentalhealthhazardrelatedtovolcanicdegassinginVanuatu.pdf


Annex 2. List of enumerators

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Expertise</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>James Wasi</td>
<td>DARD, MALFFB</td>
<td>Agriculture</td>
<td>Port Vila</td>
</tr>
<tr>
<td>Lawrence Nimoho</td>
<td>RRU, MALFFB</td>
<td>Nutrition and food security</td>
<td>Port Vila</td>
</tr>
<tr>
<td>Oriane Turot</td>
<td>FAO</td>
<td>Needs assessment and food security</td>
<td>Port Vila</td>
</tr>
<tr>
<td>Gwen Tari</td>
<td>DARD, MALFFB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joel Kalnpel</td>
<td>DARD, MALFFB</td>
<td>Crop officer</td>
<td>Ambae</td>
</tr>
<tr>
<td>Glen Alo</td>
<td>UFD</td>
<td>Fishery officer</td>
<td>Santo</td>
</tr>
<tr>
<td>Turani Lui</td>
<td>DARD, MALFFB</td>
<td>Crop officer</td>
<td>Ambae</td>
</tr>
<tr>
<td>George Tari</td>
<td>DARD</td>
<td>Crop officer</td>
<td>Ambae</td>
</tr>
<tr>
<td>Dr. Israel</td>
<td>DARD, MALFFB</td>
<td>Livestock officer</td>
<td>Santo</td>
</tr>
<tr>
<td>Malcolm Tamba</td>
<td>DARD, MALFFB</td>
<td>Fishery officer</td>
<td>Ambae</td>
</tr>
<tr>
<td>Tari Bridy</td>
<td>DARD, MALFFB</td>
<td>Fishery officer</td>
<td>Ambae</td>
</tr>
<tr>
<td>Jimmy Pakoa</td>
<td>DARD</td>
<td>Crop officer</td>
<td>Ambae</td>
</tr>
<tr>
<td>Sam Naiu</td>
<td>DARD, MALFFB</td>
<td>Livestock officer</td>
<td>Tanna</td>
</tr>
<tr>
<td>Jacob Taiki</td>
<td>DARD, MALFFB</td>
<td>Ambae official Counsellor</td>
<td>Ambae</td>
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