Toolkit for Climate Change Vulnerability Assessment

And Identification of Adaptation Options

for the Municipal Council of Vacoas Phoenix
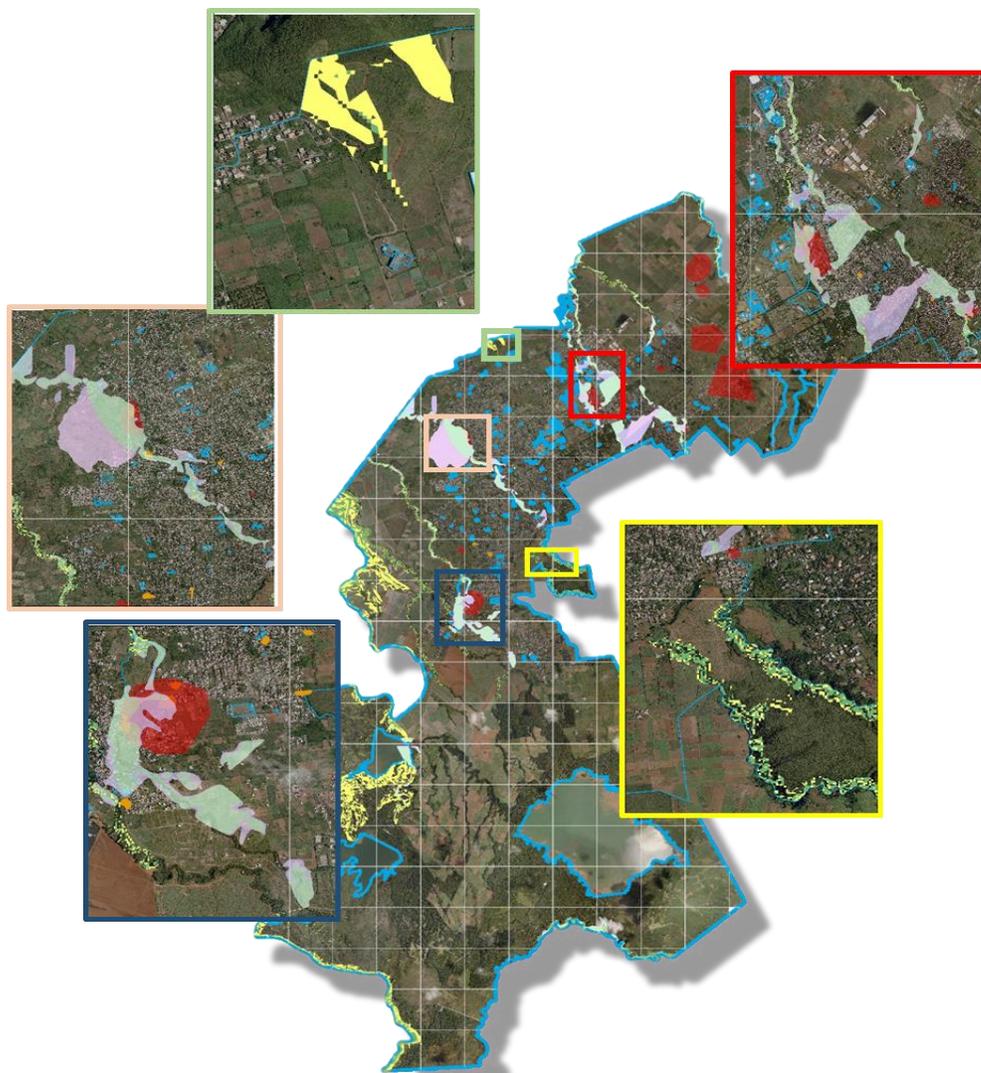
JULY 2014

Ministry of Environment and Sustainable Development
and
Municipal Council of Vacoas Phoenix

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Executive Summary

As a Small Island Developing State, Mauritius is highly vulnerable to adverse effects of climate change. The impacts of climate change and extreme weather events, such as torrential rains causing inundations, landslides and water logging in low lying areas, as well as accelerating sea level rise are worsening. As climate is changing, so is the operating environment for Local Authorities. The Local Authorities will need to be armed with appropriate proactive responses to the emerging climate threats. Local Authorities' response to climate change requires a dual approach:

(i)   Adjusting to existing approaches and practices such that vulnerability and risks associated with climate change can be reduced and opportunities realised (commonly referred to as adaptation); and

(ii)   Reduction of emissions of greenhouse gas (commonly referred to as mitigation).

The two approaches are complementary and need to be considered concurrently. This toolkit lays emphasis on vulnerability assessment and identification of adaptation options in the area falling under the jurisdiction of the Municipal Council of Vacoas Phoenix (MCVP). It is meant to be used in conjunction with the guidelines for Mainstreaming Climate Change in the Building and Land Use Permit, which deals both with climate change adaptation and mitigation.

This toolkit has been designed to strengthen the internal capacity of both the council and its staff to manage the local impacts of climate change. It is also meant to help the Council to proactively address the prevention, protection and preparedness to the adverse effects of climate change and extreme events. It will help to:
- Identify, assess, prioritise and manage risks related to climate change;
- Pave the way towards engaging with communities potentially at risk; and
- Adopt climate resilient adaptation plans.

The toolkit is in line with recommendations of National Climate Change Adaptation Policy Framework for the Republic of Mauritius (2012), which calls for building capacity of institutions and train their human resources to help them adapt to the adverse effects of climate change.

The MCVP is one of the 12 local authorities in Mauritius which has volunteered for the preparation of such a toolkit. Similar toolkits will be prepared for other local authorities as well.

MCVP is currently at risks due to adverse climatic events. The average temperature at Vacoas during the decade 1998-2007 was higher than that of the 1951-1960 period by 0.74˚C. The Second National Communication (2010) has pointed out to a more rapid increase in summer temperatures than winter ones and the number of days with maximum temperatures above the threshold value of 30˚C is on the rise. The Second National Communication has also indicated that there is a decrease in rainfall amount between the periods 1931-1960 and 1971-2000. This finding has also been confirmed by the risk assessment and projections made under the DRR Strategic Framework and Action Plan (2013). It has also been observed that there is higher precipitation during the months of May to October, which is usually a cool and dry period. In addition, rainfall variability has risen together with an increased occurrence of high intensity rainfall events. This condition favours flash-floods and consequently run-off to the detriment of recharge of aquifers. The intensity and frequency of extreme precipitation events are likely to increase in the future.

Key findings in terms of vulnerabilities and climate risks for the MCVP:

(i)   Part of Camp Bellin, the regions adjoining Vingta, Solferino and the area adjoining Ramputh Lane, St Paul are highly at risk from flooding. These areas have been reported to be flooded since 2001 (source: NDU). They are also reported to be flooded during heavy rain events. These areas have been identified by the DRR report for their risk of flooding.

(ii)   The following infrastructures could be at risk from flooding hazards:
- Schools in particular at Henrietta and at Mesnil;
- Health Centres at Henrietta, La Caverne and Castel;
- Women Centre at Phoenix;
- Houses in the regions of Solferino, Camp Fouquereaux, Phoenix and Lallbahadoor Shastri (Candos);
- 7.97 km of road based on a return period of 25 years

(iii) The following regions could become at risk from landslides:

- Candos Hill and
- La Vanille.

Key adaptation measures proposed include:

- Adopt climate sensitive building design, where practicable, that allows cooling through natural ventilation and that consumes low energy through proper building orientation.
- Control development within vulnerable and environmentally sensitive areas. Due care to be taken by the MCVP while delivering Building and Land Use Permit for developments proposed in areas identified to be potentially at risks from flooding and even landslide.
- Consider regular monitoring, maintenance and cleaning of existing drains which are located within the vulnerable areas. Monitoring could be carried out by Officers of MCVP who work regularly on sites.
- Encourage tree planting to increase sink capacity and promote a carbon-neutral town. Promote green spaces which can help in flood control. Provide greenery such as parks and green open spaces and planting along roads and around development.
- Promote rainwater harvesting for irrigation and to adapt to the risk of interruption in water supply.
- Carry awareness campaigns to disseminate information regarding vulnerable areas to the citizens, in view to enable them to take necessary precautions. Awareness media could include talks, pamphlets/flyers, websites and digital display screen.
- Strengthen the functioning of the MCVP Council through funding, staffing, capacity building and development of an evacuation plan and strategy for people living in the vulnerable areas.

The guidance of the Chairperson and inputs members of the Environment Coordination Committee Sub-Committee in particular inputs from MVCP were instrumental in developing this toolkit.

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Abbreviations

CAD   Computer-aided design

DRR   Disaster Risk Reduction and Management
             *(Reference being made to the Japanese Government funded/UNDP
             Africa Adaptation Programme project titled 'Disaster Risk Reduction
             Strategic Framework and Action Plan' was commissioned by the
             MOESD in 2012.)*

GIS   Geographical Information System

ICLEI   International Council for Local Environmental Initiatives

MCVP   Municipal Council of Vacoas Phoenix

MOESD   Ministry of Environment and Sustainable Development

QGIS   Quantum GIS

Definitions

Data Layer — Refers to data having similar characteristics being contained in the same plane or overlay (e.g., roads, rivers) of a Geographic Information System. Usually information contained in a data layer is thematically related and is designed to be used with other layers.

Dataset — A named collection of logically related data records arranged in a prescribed manner.

Digital Elevation Model (DEM) — A file with terrain elevations recorded for the intersection of a fine-grained grid and organized by quadrangle as the digital equivalent of the elevation data on a topographic base map.

Exposure — The nature and the degree to which a cell of the assessed region is exposed to significant hazards. It allows to identify and classify areas where the hazard can be in contact with the receptor.

Flooding — A general and temporary overflowing of inland water that submerges normally dry land areas or the unusual and rapid accumulation or runoff of surface waters as a result of heavy rainfall.

Floodplain — Any land area that is susceptible to being inundated by water from any source.

Flood prone Area — See Floodplain.

Geographic Information System (GIS) — A system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems.

Georeference System — An X,Y or X,Y,Z coordinate system that locates points on the surface of the earth as a reference to points on a map.

Global Positioning System (GPS) — A satellite-based navigation and positioning system that enables horizontal and vertical positions to be determined.

Hazard — An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, and other types of loss or harm.

Landslide — The movement of a mass of rock, earth or debris down a slope.

Layer — The various "overlays" of data, each of which normally deals with one thematic topic. The overlays are registered to each other by the common coordinate system of the database. In a GIS, a layer or a theme represents a specific kind of data.

Relative Risk — The relative classification of areas and targets that are likely to be affected by climate change impacts more severely than others in the same region; it is calculated from the combination of exposure and susceptibility.

Return period — The return period is an average length of time (in years) for an event (such as precipitation or discharge) of given magnitude (i.e. mm of rainfall per unit of time) to be equaled or exceeded. Return period is inversely related to the probability of the event. So for example a 1-in-100 years flood has a probability of 0.01 (1%) to occur in any given year. This does not mean that a 100-year flood cannot occur the next successive year after a flood of the same magnitude.

Susceptibility — The degree to which receptors could be affected by a given climate change hazard (e.g. sea-level rise, storm surges, coastal erosion). Susceptibility brings in a biophysical assessment of the receptors, i.e. how much these receptors could potentially be harmed given their intrinsic characteristics (in bio-physical terms).

Universal Transverse Mercator (UTM) Grid — A system of plane coordinates based on 60 north-south trending zones, each 16 degrees of longitude wide, that circle the globe.

Vulnerability – The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

1.0 Introduction

As a SIDS, Mauritius is highly vulnerable to adverse effects and variability of climate change. According to the latest World Risk Report 2012, Mauritius is among the top 15 countries with the largest disaster risk (rank 13) and is ranked 7 as the most exposed to natural hazards worldwide. Assessment carried out under the Disaster Risk Reduction Strategic Framework and Action Plan Strategy[1] commissioned by the MOESD and completed in January 2013 indicated that the impacts of climate change are likely to worsen in the future. The projections scenarios reveal the following:

❑ The average air temperature on Mauritius Island is expected to increase between 1 to 2°C by 2061-2070 compared to 1996-2005. This is in addition to the average temperature rise of 0.74 – 1.1 °C when compared to the 1961-90.

❑ The intensity and frequency of extreme precipitation events are likely to increase in the future. This could be coupled with higher precipitation during the months of May to October.

❑ Several areas in Mauritius will be exposed to flooding due to heavy rainfall. Some extent of built up areas, agricultural land, motorway, main roads and secondary roads will be affected.

As climate change is very likely to last for decades, the operative environment of Local Authorities is also very likely to change. The Municipal Council of Vacoas Phoenix is one of the 12 local authorities in Mauritius which has volunteered for the preparation of a toolkit on Climate Change Vulnerability Assessment and Identification of Adaptation Options. The MCVP is located in the district of Plaine Wilhems. It acceded to the status of a town in 1963 and was raised to the status of a Municipality in 1968. The original Municipal Council area which was 13.22 km^2 has been extended to 106 km^2 in 1991 by annexing of adjoining areas such as Belle Terre, Camp Fouquereaux,

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[1] Climate projections have been simulated using RCP4.5and RCP8.5 radiative forcing scenarios developed in the framework of the AR5 IPCC activities. RCP4.5 assumes a high income growth, low population growth, gains in clean energy and efficiency resulting from aggressive carbon pricing. RCP8.5 is a high emissions scenario, high population growth, slow per capita income growth, little convergence by high and low countries: a coal intensive energy scenario.

CinqArpents, Highlands, Henrietta, La Marie, Glen Park, Petit Camp, Valentina, Quinze Cantons, Solferino and Hollyrood. The total number of localities is 44. The population which was 42,000 in 1963 has now reached about 103,000 with an approximately 29,081[2] households which covers approximately a surface area of 26 km^2.

The town of Vacoas/Phoenix has a cool climate which is very conductive for agriculture and also offers a very pleasant living environment. One can find vast agricultural zones, around 49 km^2, in the town area where sugar cane and vegetables are grown on a large scale, side with residential areas which offer modern facilities to the inhabitants.
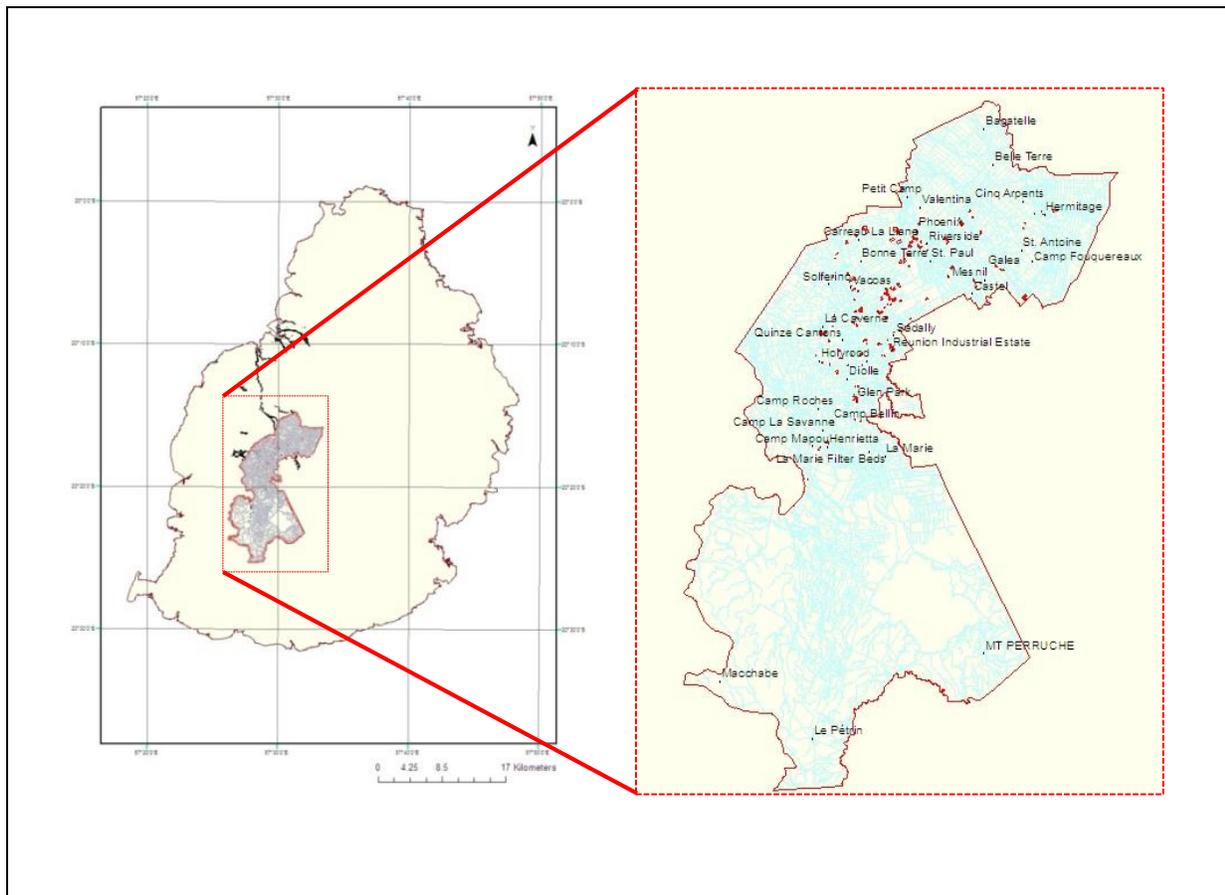
Figure 1: *Boundary of the MCVP*

[2] 2011 Housing and Population Census, Statistics Mauritius.

2.0 Purpose

The purpose of this toolkit is to assist the MCVP to undertake climate change vulnerability assessment within its jurisdiction and to identify appropriate adaptation measures for implementation, monitoring and reporting. It will also help to:

•   Identify, assess, prioritise and manage risks related to climate change; and

•   Engage its communities in risk management processes.

3.0 Methodology and Approach

The approach adopted, with stakeholders participatory process enshrined, for the vulnerability assessment and identification of adaptation options for the MCVP was the following:

(i)   **Establishment of the context**

The objective of the climate change adaptation process was defined and the relevant stakeholders were identified.

(ii)   **Identification, Analysis & Evaluation of the risks**

The risks were identified, analysed and evaluated based on

- *Working sessions with MCVP; and*
- *GIS maps generated from projections made in the DRR Strategic Framework and Action Plan*

(iii)   **Development of adaptation options**

Based on the risks identified and evaluated, climate change adaptation options were formulated.

(iv)   **Development of an action plan**

An adaptation action plan will have to be identified to treat the identified risks. Each action includes guidance as to who will implement the action, what resources are needed and when each action should be implemented.

(v)   Implementation of adaptation action plan

Once approved, the actions will have to be implemented according to the schedule set out in the action plan.

(vi)   Review of the progress

Progress will have to be monitored in view to achieve the ideal outcomes throughout the implementation process.

(vii)   Revision of the adaptation action plan
The adaptation action plan will have to be reviewed and revised as necessary, based on the lessons learnt from the progress.

The above steps are depicted in the ***Figure 2*** below.

Figure 2: *Toolkit process diagram*

Source: ICLEI Oceania Local Government Climate Change Adaptation Toolkit
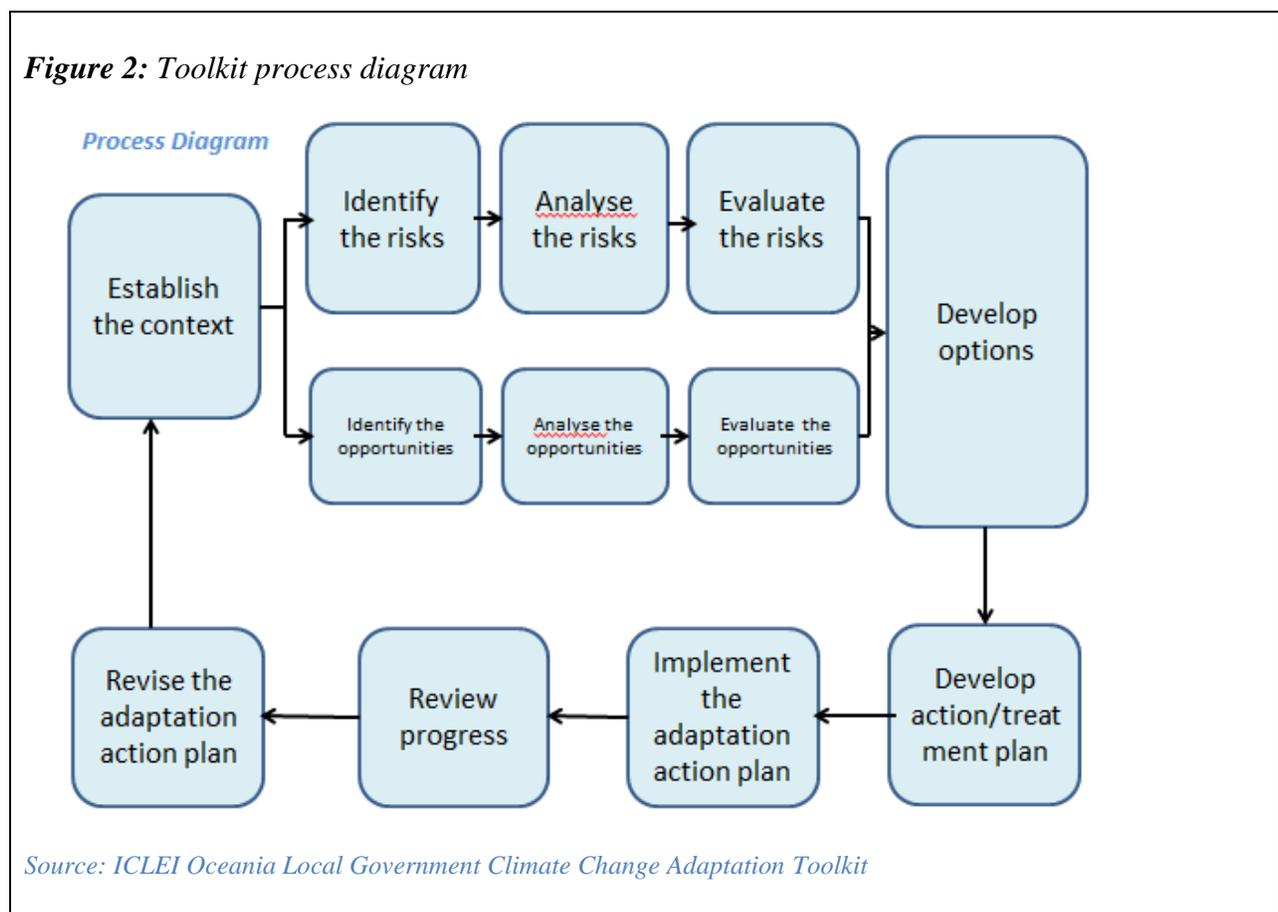
The approach and methodology for the identification, analysis and evaluation of risks were based on:

(i)   Climate modeling and projections for different scenarios covering the time period up to year 2070 and using historical meteorological data was carried under the DRR strategy. The

latter also produced vulnerability maps and Geographical Information System (GIS) data with regard to flooding, landslides and coastal inundation due to sea level rise/surges. The data have been applied for the preparation of this toolkit.

(ii)   Water accumulations paths were generated in GIS by using a Digital Elevation Model (10 m horizontal resolution and 1m vertical resolution) acquired as part of the DRR project from the Ministry of Housing and Lands. The water path data provide indicative locations of water passages in case of heavy rain. This data has also been applied for the preparation of this toolkit.

(iii)   A series of consultative meetings and working sessions were held with the representatives of the MCVP. Site visits and field surveys were carried out by the MCVP to gain more up to date information for inclusion in this toolkit. Valuable information and data, including for currently known flood areas, drainage systems and buildings at risk were gathered during these meetings.

(iv)   Data in CAD format containing the MCVP boundary, roads and street names were shared by the MCVP. Same were converted into GIS shapefiles for use in this toolkit.

(v)   The DRR data, the new data generated, as well as the other data and information obtained through consultative meetings were integrated into a GIS package for the MCVP.

3.1 Conducting Vulnerability Assessment

The simplified step by step procedures for using GIS and updating the data are given at Annex. In order to view the data, update the data, create new data or make/print maps, the simplified step by step procedures should be consulted.

- The processed GIS data have been provided in the folder *'Vacoas_GIS_Data_Final'* within the CD. The image below shows the content of that folder.
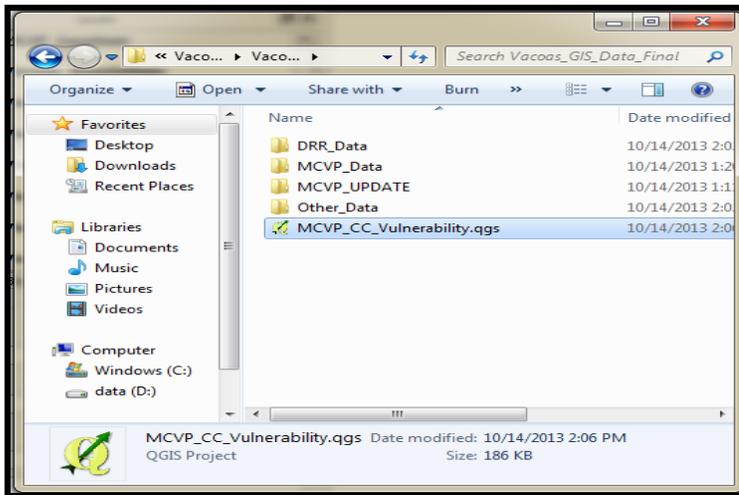
Figure 3: Capture showing folder containing 'Vacoas_GIS_Data_Final'

- The GIS data already been saved to their relative paths. This means the folder can be copied to any computer where the Quantum GIS 2.0.1 has been installed. For opening the MCVP data, double click on the MCVP_CC_Vulnerability.qgs within the folder. The MCVP data will open as given in the image below:
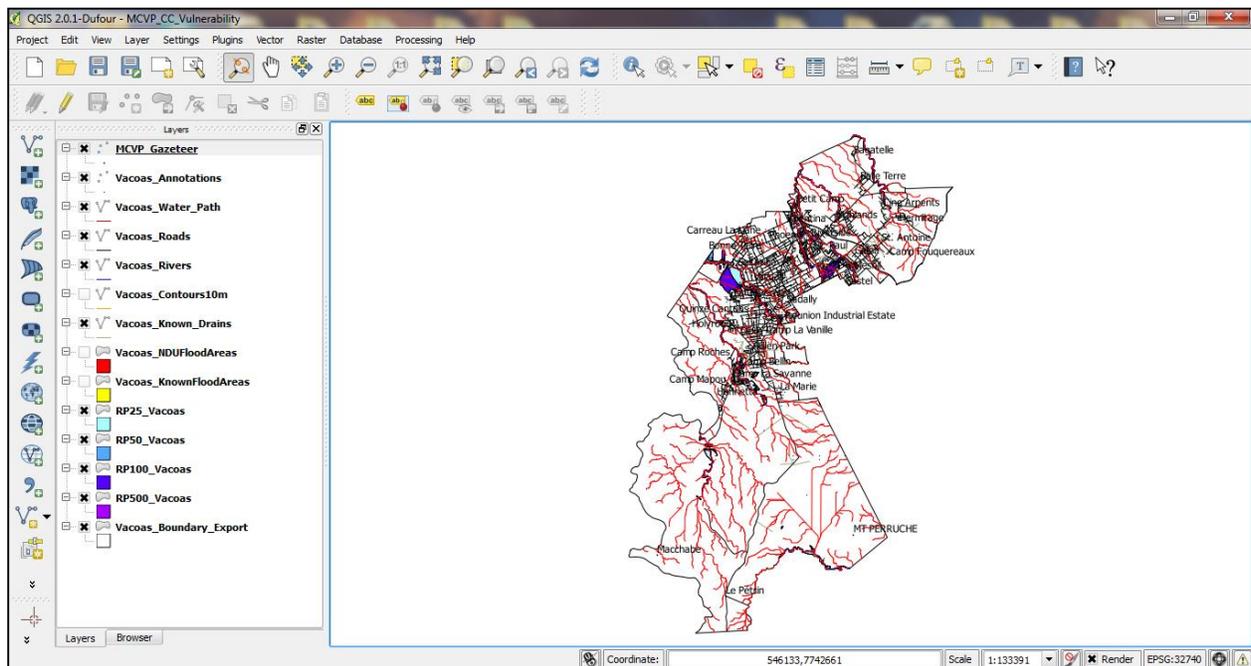
Figure 4: Capture showing the GIS map for MCVP

- For updating new observations made on sites, including for new flooding areas and new drains constructed, the data should be saved to the folder '*MCVP_UPDATE'*. The updating

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need to be performed by a trained Officer of the MCVP and preferably immediately after an event or completion of works.

3.2   Interpretation and Liability

The GIS base data provided by the MOESD are meant for internal use by the MCVP. The interpretation of the vulnerability maps shall be considered as the sole interpretation of the MCVP. The MOESD shall not be liable for any direct, indirect, incidental or consequential damages, including but not limited to loss of data, arising out of the use of or the inability to use or due to misinterpretation of the data provided, or any misuse of the GIS software provided.

4.0 Findings

4.1 Flood Hazard Mapping

Analysis was conducted for flood hazard events characterised by return periods of 25, 50, 100, or 500 years from the DRR project, the last two being extreme events. The table below shows the areas of MCVP that could be affected by flooding hazards according to event with different frequency recurrence:

Flood Hazard Level		
Return Period of flood Event	Probability	Area affected
25 years	4 percent annual chance flood	1.761 km^2
50 years	2 percent annual chance flood	1.856 km^2
100 years	1 percent annual chance flood	2.969 km^2
500 years	0.2 percent annual chance flood	3.262 km^2

Table 1: *Flood Hazard Level and Areas affected accordingly.*

The key findings for the MCVP are:

(i)   Most of the currently known flood areas in the MCVP are located within the natural water paths.

(ii)   A few flood prone areas already identified by the DRR project have been reported by the MCVP to be flooded during heavy rains.

(iii)   Part of Camp Bellin, the area adjoining Vingta, Solferino and the area adjoining Ramputh Lane, St Paul are highly at risk from flooding. These areas have been reported to be flooded since the survey undertaken by the NDU in 2001. They are also reported to be flooded during heavy rain events and they are located within the DRR identified flooding areas.

(iv)   It is to be noted that the Camp Fouquereaux region is situated in a highly vulnerable area even though it is not located within the DRR identified flooding areas with an estimated 0.287 km^2 of liable built up areas.

The maps given below show relevant parts of the MCVP which could be affected by flooding. The maps should be interpreted based on the keys provided in the legend. For the vulnerability assessment of specific sites, more details for the various return periods should be gathered from the GIS package provided.
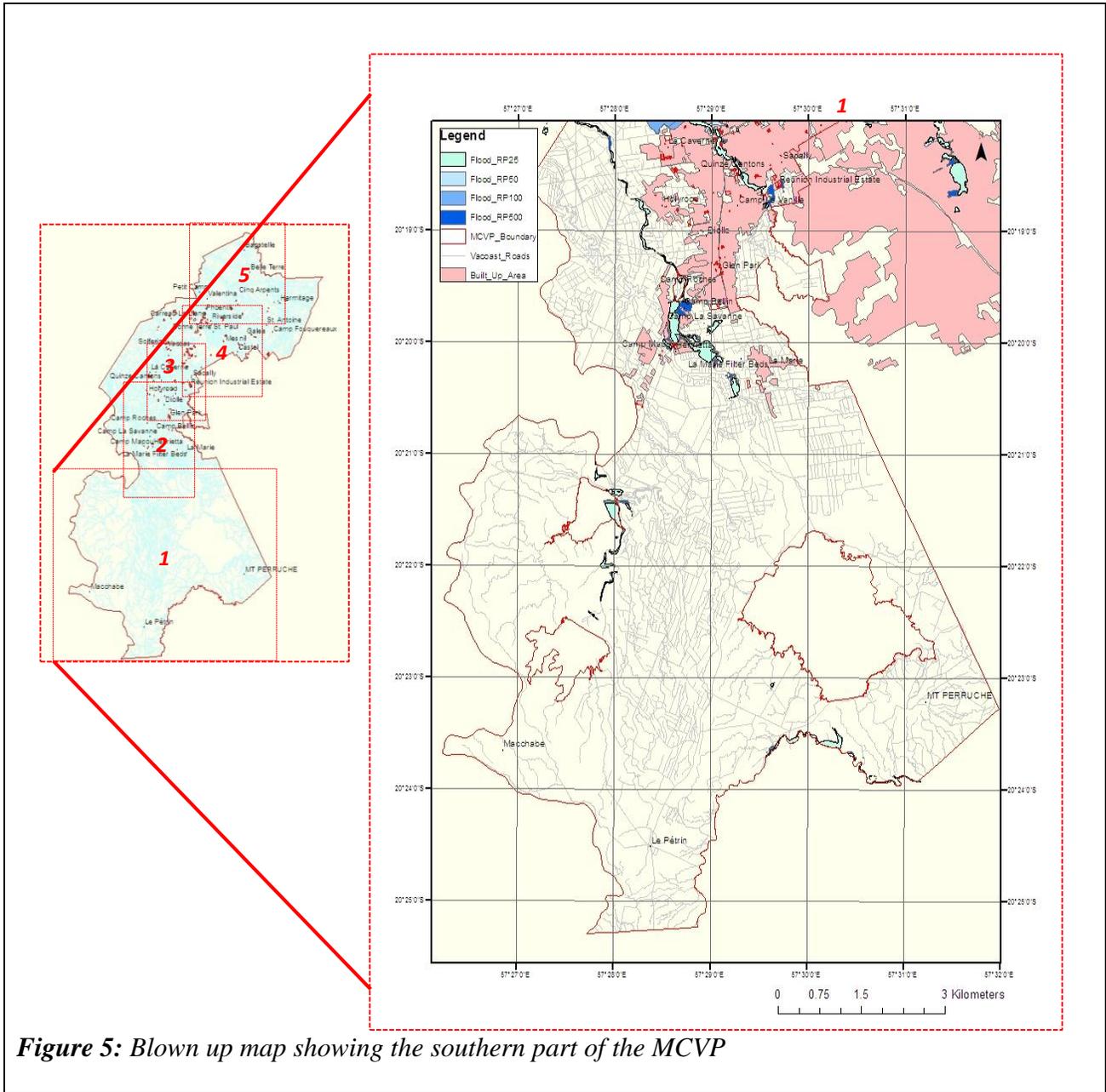
Figure 5: *Blown up map showing the southern part of the MCVP*
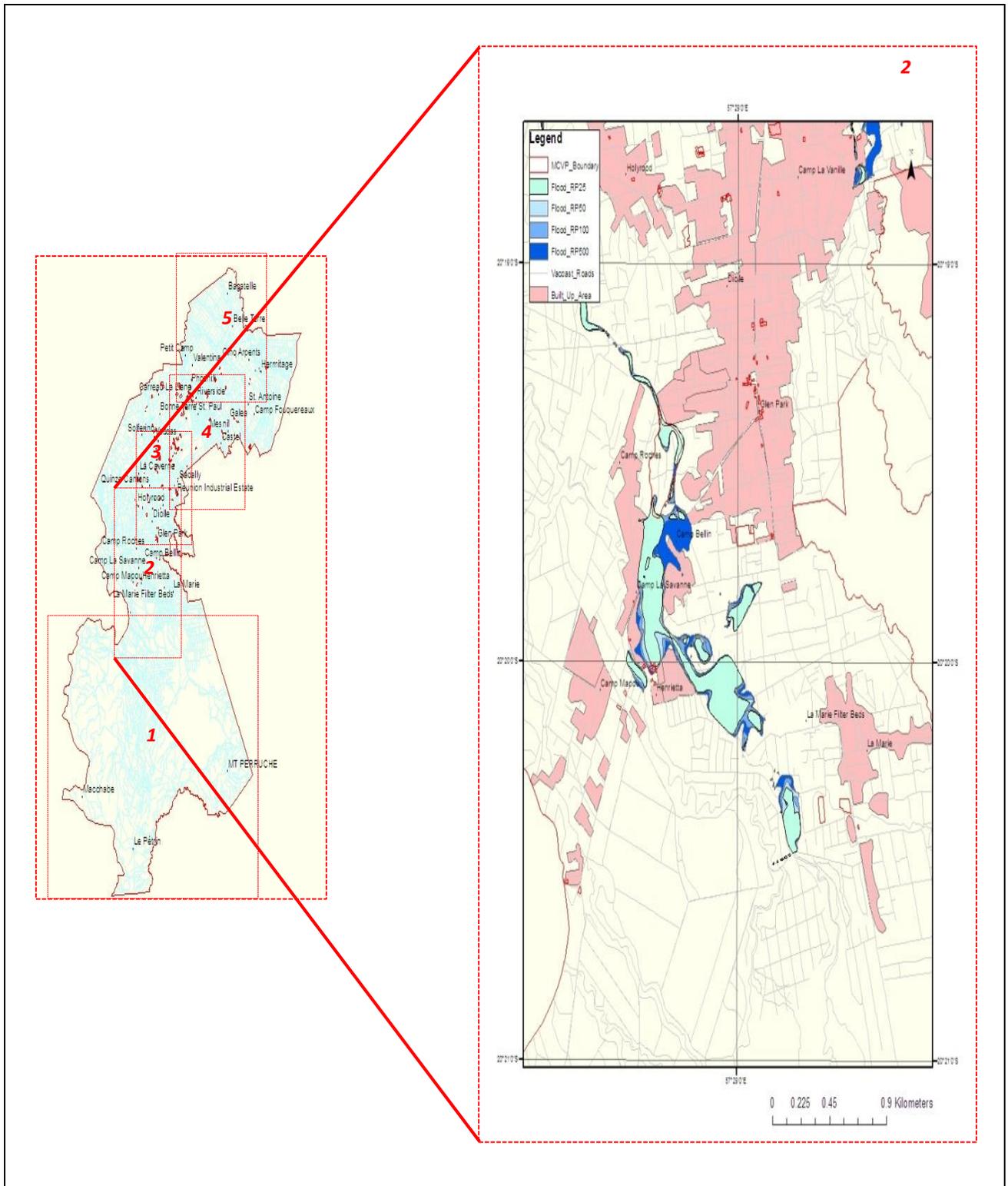
Figure 6: Blown up map showing the central part of the MCVP
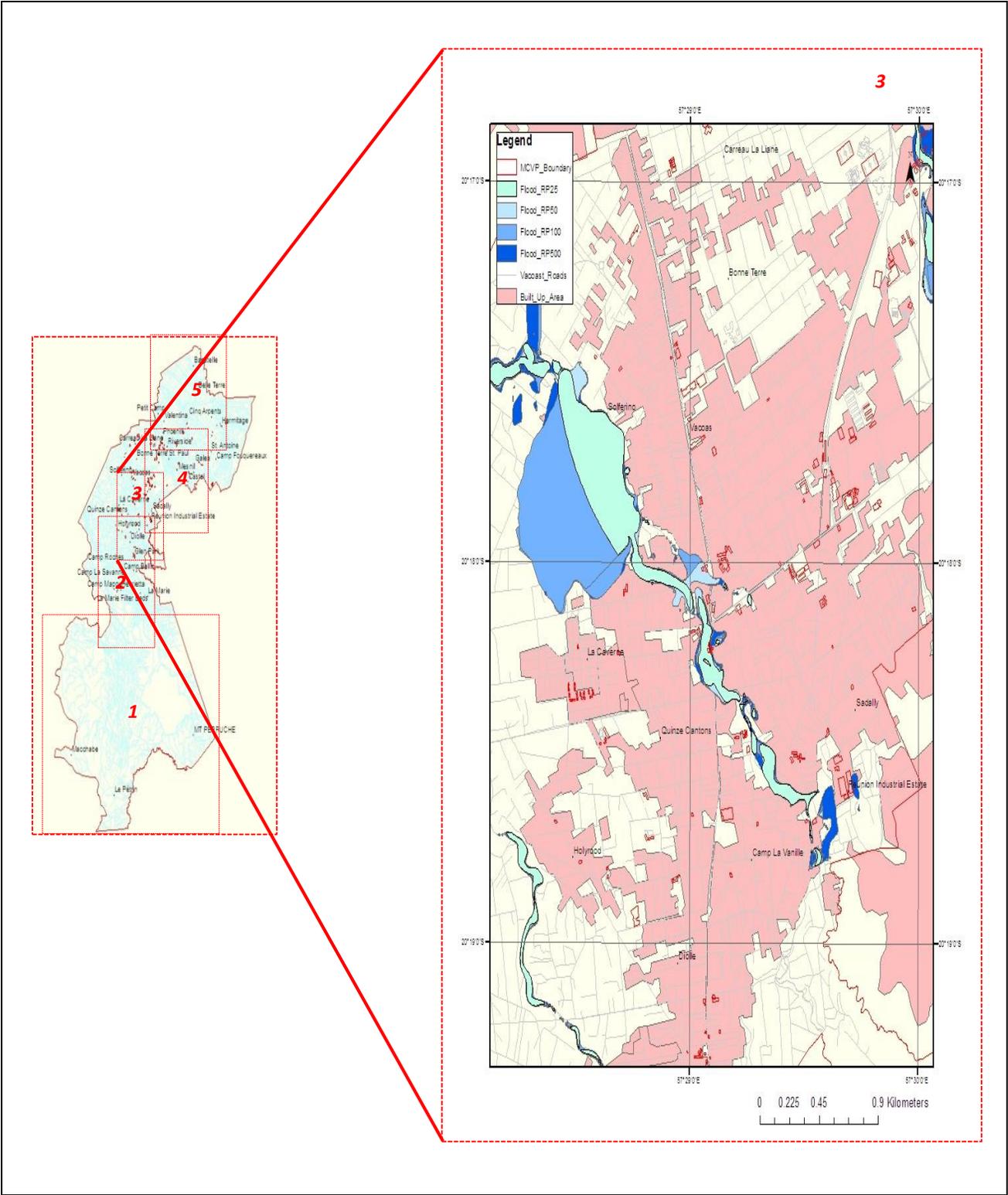
Figure 7: Blown up map showing the northern part of the MCVP

Figure 8: Blown up map showing the northern part of the MCVP
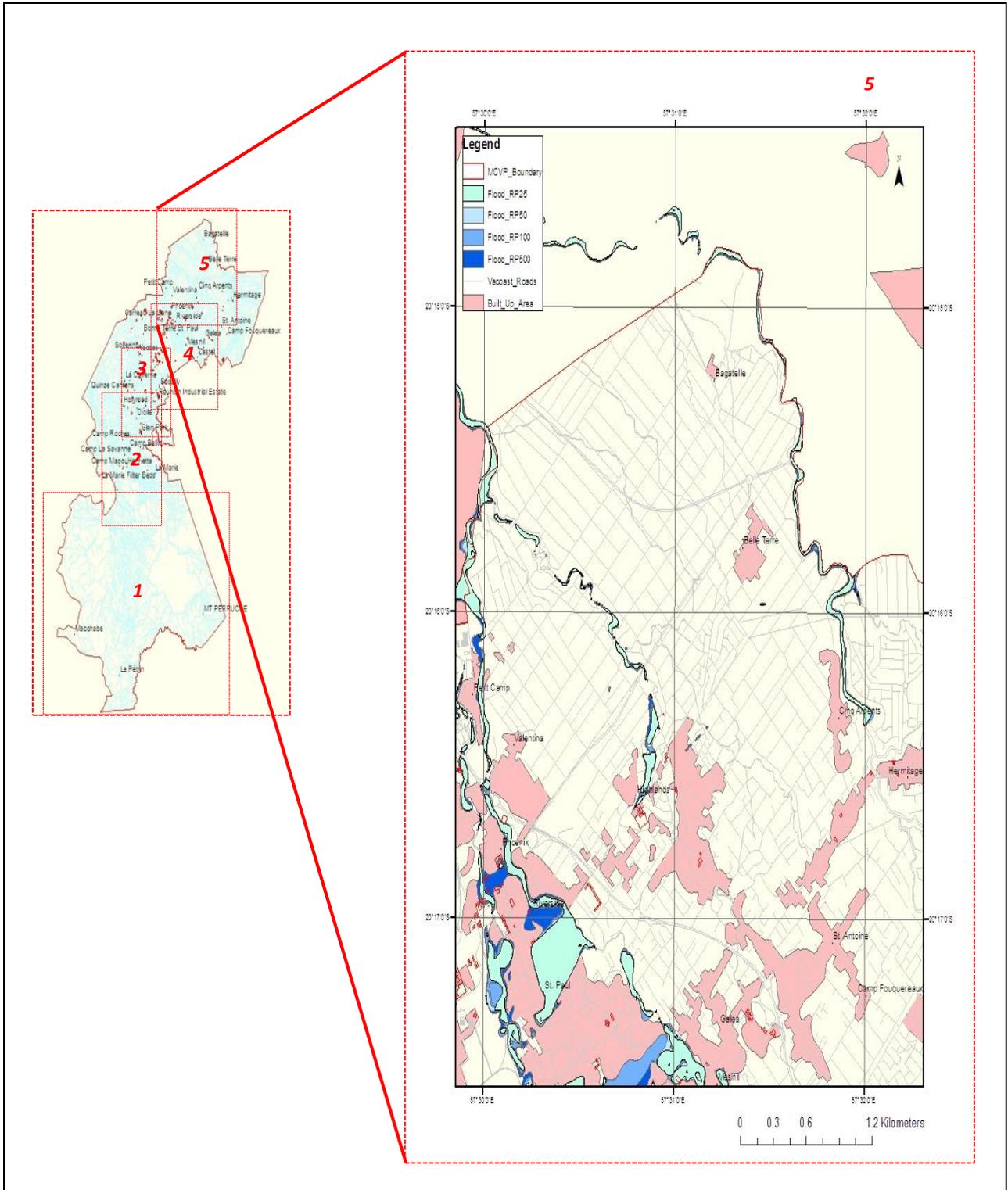
Figure 9: *Blown up map showing the northern part of the MCVP*

4.1.1 Flood Hazard Mapping - Henrietta Area

Part of Camp Bellin has been described as being highly at risk from flooding. It is situated in the region of Henrietta. The latter itself is located within a DRR identified flooded area along the Du Rempart West river, as can be observed on the map below.
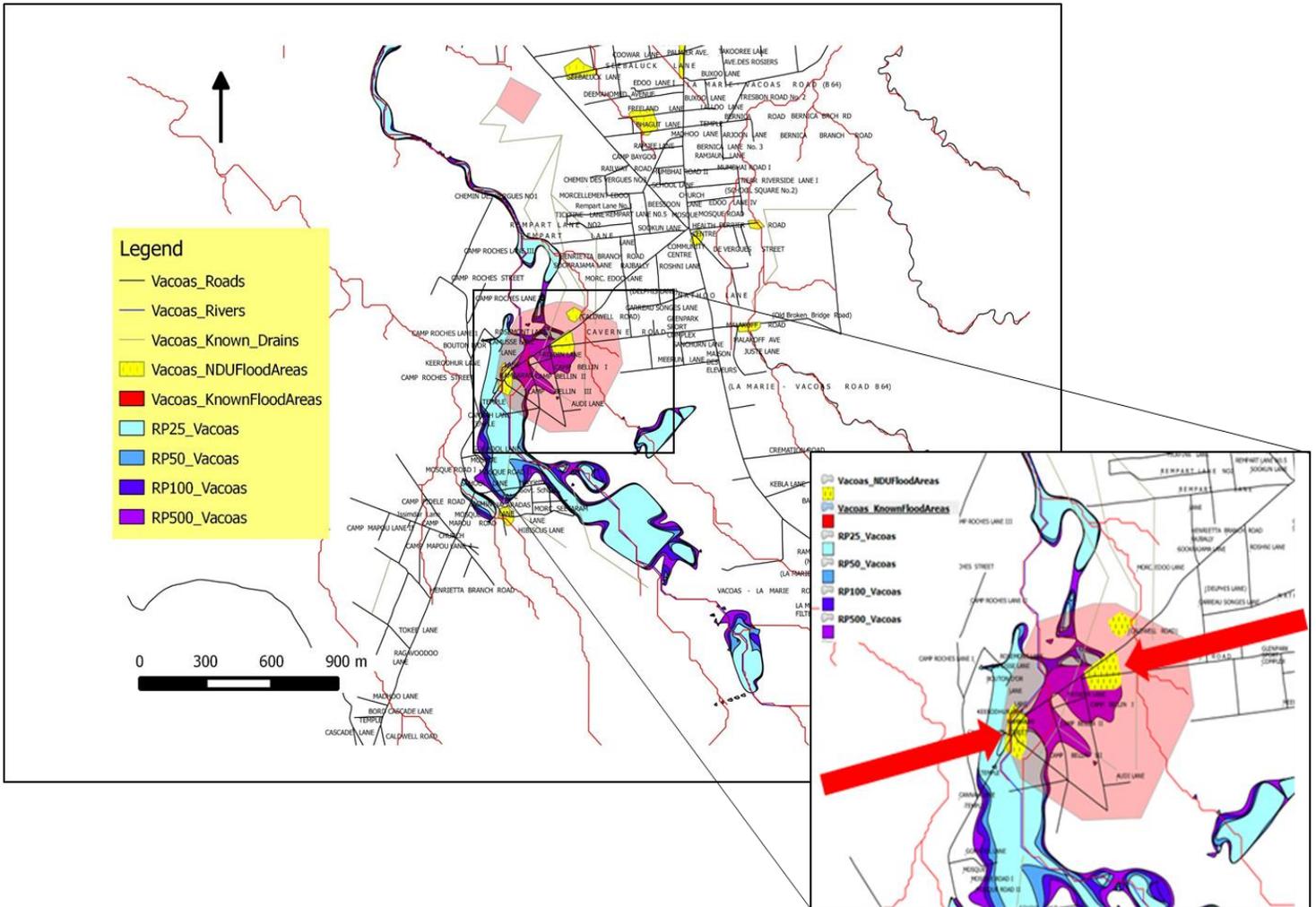
Figure 10: *Map showing area highly at risk from flooding at Camp Bellin. The red arrows show the part of Camp Bellin has been reported to be flooded since 2001 by the NDU*

The table below summarizes the areas of land that could be affected for different return period for the region around Henrietta. The flooded area is divided taking into account their land use.

Land-use	RP 25	RP 50	RP 100	RP 500
Built up area (km^2)	0.128	0.137	0.145	0.219
Agricultural fields (km^2)	0.0875	0.153	0.218	0.233
Roads (km)	2.63	2.7	2.73	2.76

Table 2: *Areas of land at Henrietta affected by flooding for different return periods*

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4.1.2 Flood Hazard Mapping – Solferino Area
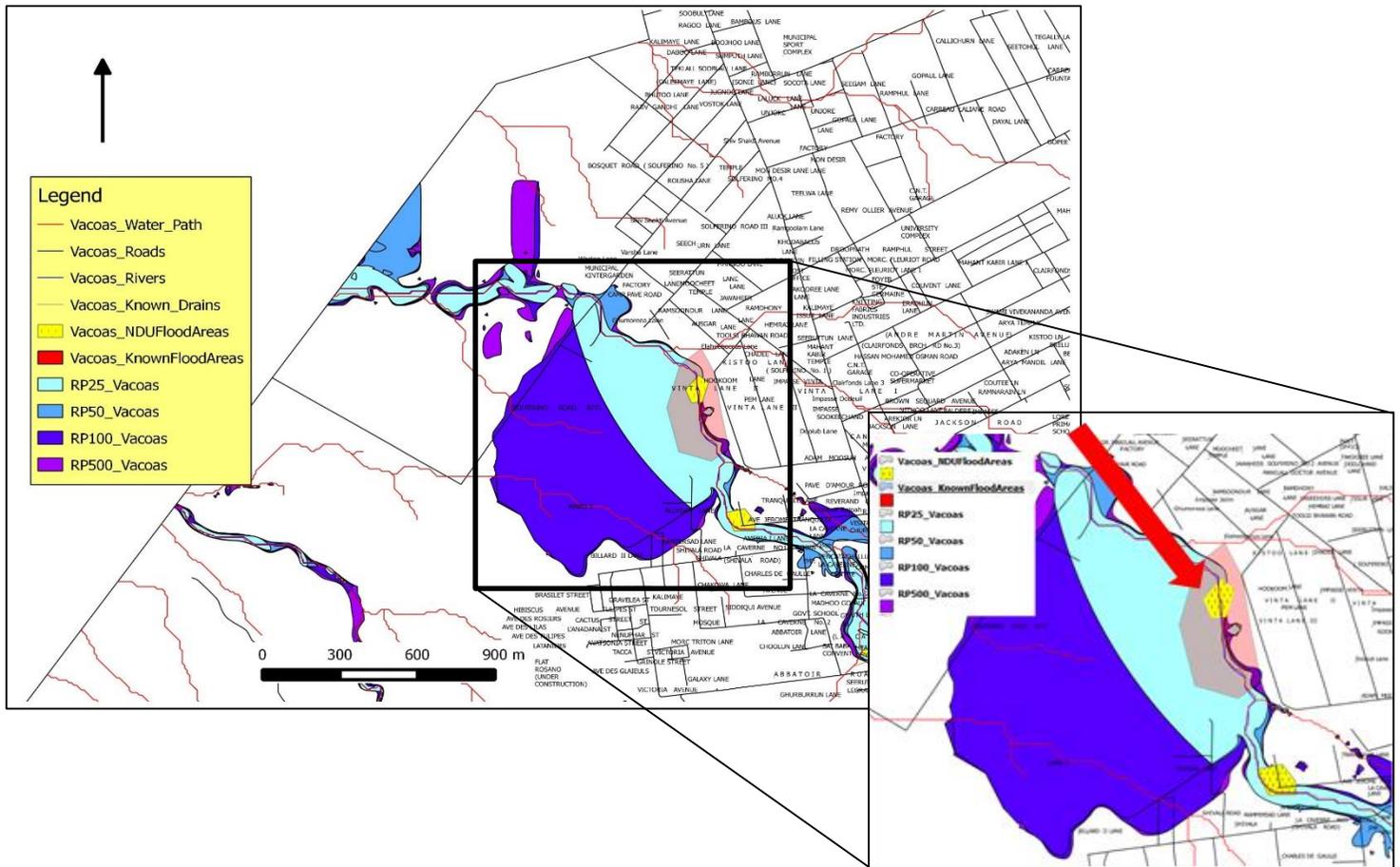
Figure 11: *Map showing area highly at risk from flooding at Vingta, Solferino. The red arrow show the part of the region at Vingta has been reported to be flooded since 2001 by the NDU*

At Solferino, Vingta is particularly at risk to flooding. The table below summarizes the areas of land that could be affected for different return period for the region around Solferino.

Land-use	RP 25	RP 50	RP 100	RP 500
Built up area (km$^{2)}$)	0.102	0.115	0.128	0.155
Agricultural fields (km$^{2)}$)	0.289	0.300	0.690	0.76
Roads (km)	1.55	2.00	3.30	3.89

Table 3: *Areas of land at Soferino affected by flooding for different return periods*

4.1.3 Flood Hazard Mapping - Phoenix and St Paul Area
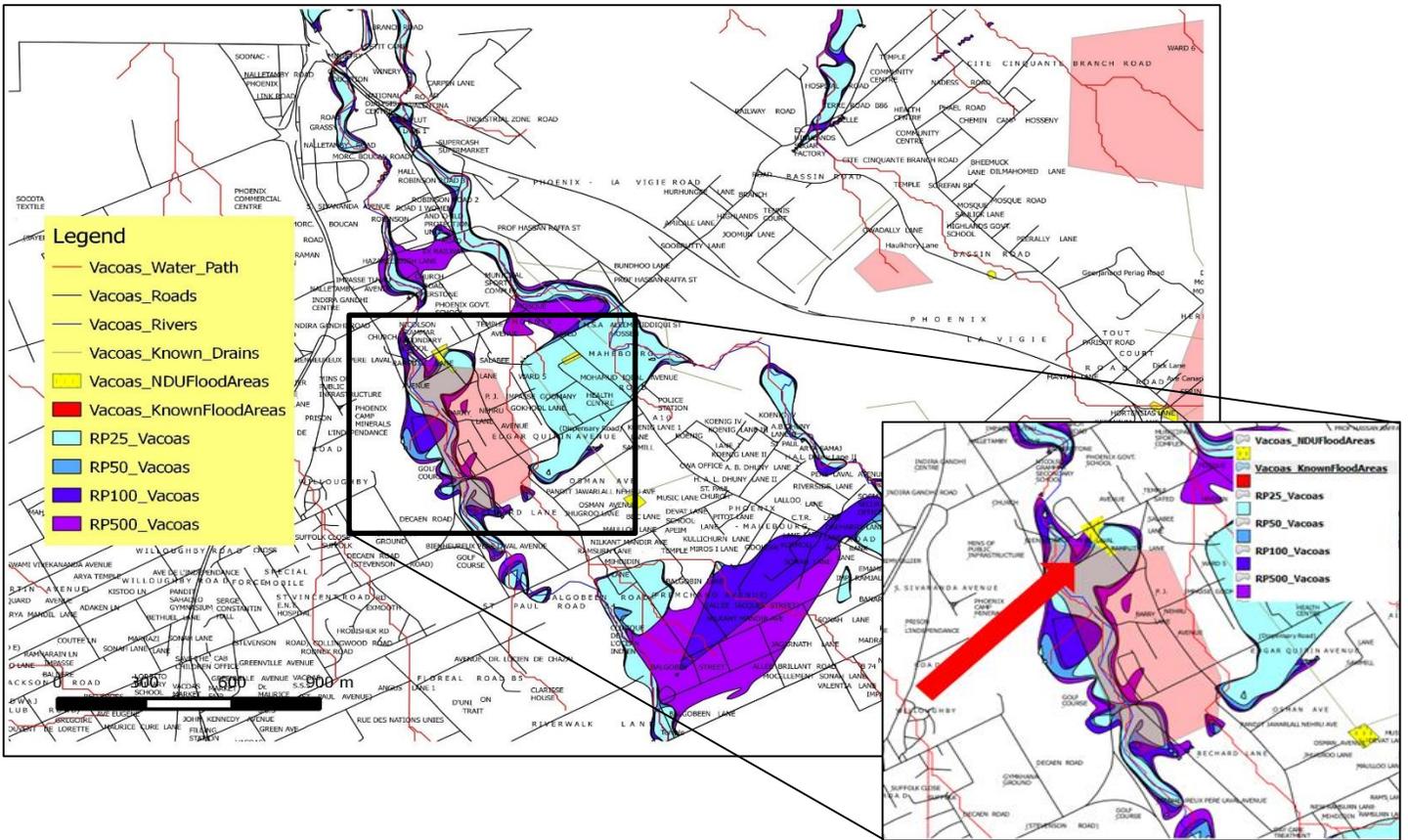
Figure 12: *Map showing area highly at risk from flooding at Ramputh Lane, St Paul. The red arrow show the part of the region has been reported to be flooded since 2001 by the NDU*

Ramputh Lane in St Paul is considered to be highly prone to flooding. It is reported to be flooded during heavy rain events. The table below summarizes the areas of land that could be affected for different return period for the region around Phoenix and St Paul.

Land-use	RP 25	RP 50	RP 100	RP 500
Built up area (km^2)	0.415	0.455	0.506	0.679
Agricultural fields (km^2)	0.061	0.065	0.072	0.112
Roads (km)	3.79	4.21	4.85	6.64

Table 4: *Areas of land at Phoenix and St Paul region affected by flooding for different return periods*

4.1.4 Risk-Exposed Elements

In addition to build up areas and agricultural fields, public infrastructures can also be at risk during flooding. The table below shows the number of infrastructures which could be affected by flood.

Infrastructure	Region		
	Henrietta	Solferino	St Paul/ Phoenix
School	1	0	1
Medical facilities	1	1	1
Bridges	2	3	2
Police Station	0	0	1
Women Centre	0	0	1

Table 5: *Number of infrastructures at risk from flooding.*

Risk Level

Medium	🟨
High	🟧
Very High	🟥

Type	Risk Level	Location
Bridge	🟥	Henrietta Bridge
Bridge	🟥	Vantard Bridge
Bridge	🟧	La Caverne Bridge
Bridge	🟨	Abattoir Bridge
Bridge	🟥	John Kennedy Bridge
Bridge	🟥	Near Alleemiah
Bridge	🟨	Highlands near Moulin
Primary School	🟥	Henrietta Government School
Primary School	🟥	Mesnil Government School
Community Health Centre	🟨	Henrietta
Community Health Centre	🟥	La Caverne
Community Health Centre	🟥	Castel
Police Station	🟨	Phoenix
Women Centre	🟨	Phoenix
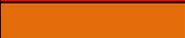
4.2 Landslide Mapping

Landslide is the movement of a mass of rock, earth or debris down a slope. The distribution of landslides is mostly controlled by slope, planar and profile curvature, drainage pattern, vegetation, lithology and soil.[3] Susceptibility maps generated for rapid earth flows, rock falls and landslides have been added to produce a landslide hazard map. As a result the hazard map in Mauritius has been classified onto four main classes as shown in the table below.

Class	Value
1	Low
2	Medium
3	High
4	Very high

Table 6: Classes for the hazard map – Mauritius.

Considering maps produced by GIS and surveys carried out by the MCVP two areas have been identified as being at risk from landslide, the region around Candos Hill and the one nearby La Vanille as can be seen in the figures below. Pictures from Google Earth have been included for ease of understanding.
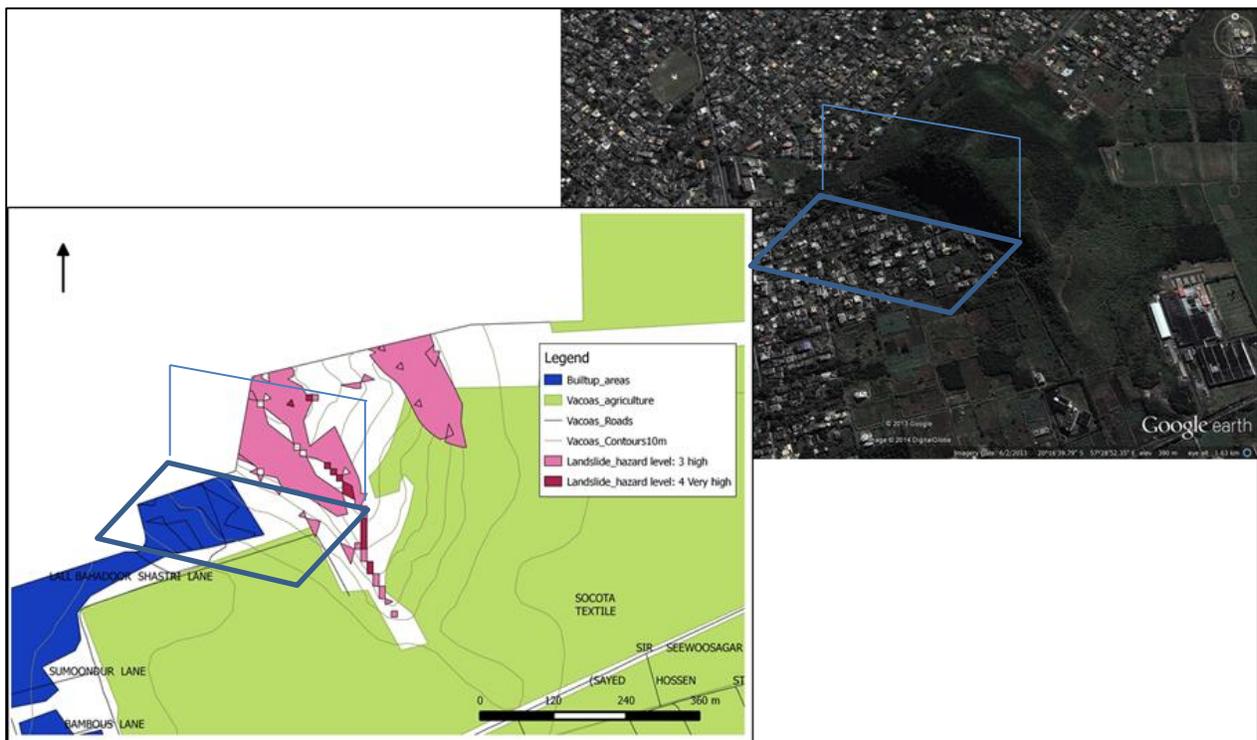
Figure 13: Map showing area highly at risk from landslide at Candos.

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[3] DRR STRATEGIC FRAMEWORK AND ACTION PLAN,2013 pg 122
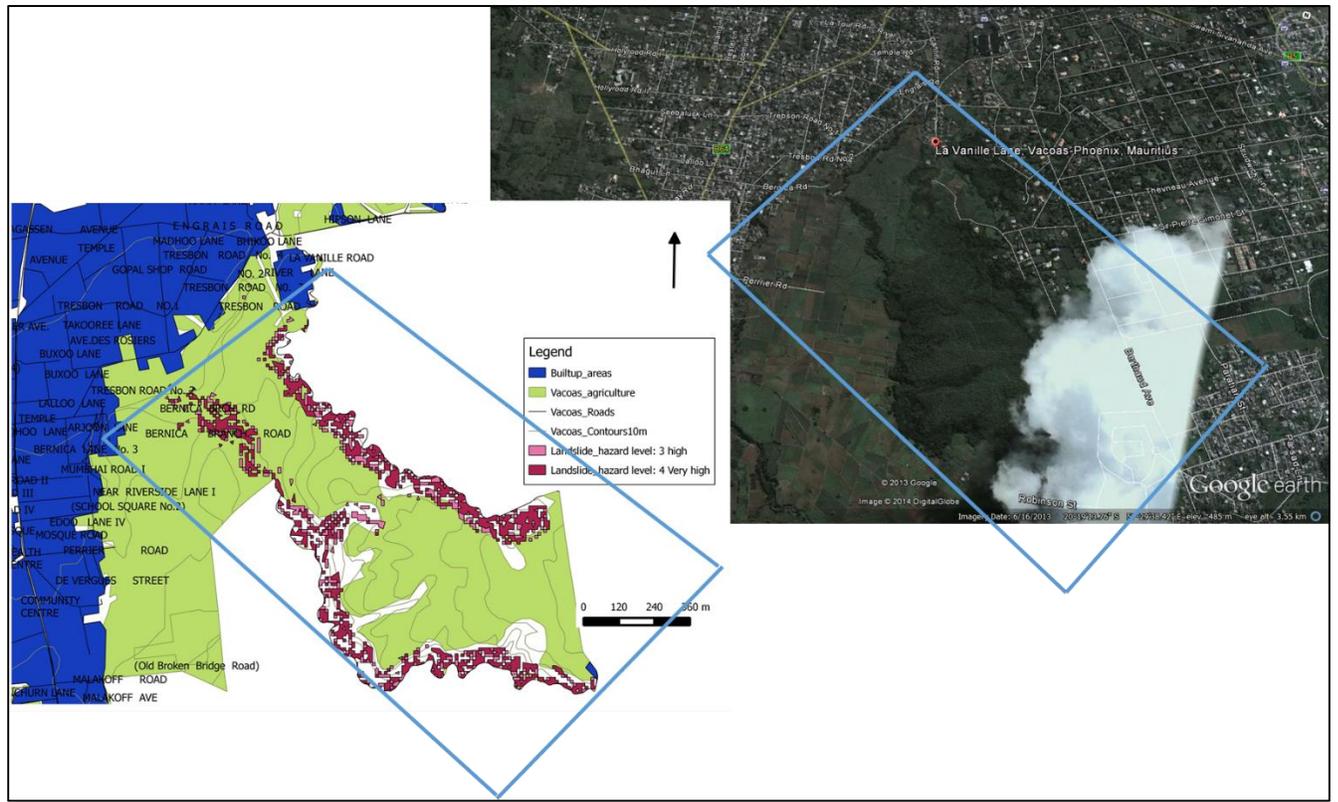
Figure 14: *Map showing area at risk from landslide at La Vanille.*

Part of Candos Hill is highly at risk from landslides due to earth flows and soil creep. The areas at risk at Candos are mainly built up areas. Figure 7 shows the region at risk at La Vanille. As can be observed on the map, the area is mainly agricultural.

4.3 Other Potential Impacts of Climate Change in the MCVP

4.3.1 Other Infrastructures at risk

- Pavements along the roads may be impacted;
- Waste water networks, storm water drains may overflow or be blocked;
- Buildings may be affected from the impacts of wind, flood and cyclone.

4.3.2 Recreational facilities

- Increased costs associated with operation and maintenance costs of public; amenities/recreational sites due to storm damage;
- Open space and sports grounds may be damaged leading to temporary closure.

4.3.3 Agriculture (farmers)

- Agricultural production may be affected by either flooding or drought;
- Occurrence of pests may be increased by variation in temperature and precipitation.

4.3.4 Water Supply

- Water supply may be affected due to variability in rainfall;
- Flooding can block water networks with debris resulting in interruption in water supply.

4.3.5 Health impacts

- High temperatures increase incidence of food and water-borne diseases.
- Exposure to extreme weather, e.g. heatwaves can have an impact on the health;
- Extreme rainfall events may transport contaminants into waterways and drinking water supplies.
- Increased intensity of extreme events may lead to an increase in the number of injuries.

5.0 Key Adaptation Options

Climate Change adaptation is an ongoing process. Suggested actions are categorised under the general themes presented below:

5.1 General Policy for a Climate Resilient MCVP

- Use of appropriate development control measures in vulnerable areas.
- Mainstream climate change into strategic planning, such as in the outline scheme and other planning tools.
- Set carbon neutral target.
- Promote appropriate sustainable consumption practices including energy efficiency and conservation practices and equipment.

5.2 New Buildings and Infrastructure

- Where practicable, adopt climate sensitive building design that allows cooling through natural ventilation and that consumes low energy through proper building orientation.
- Design buildings taking into consideration future climate change impacts and incorporation of future adaptation.
- Control development within vulnerable and environmentally sensitive areas. Due care to be taken by the MCVP while delivering Building and Land Use Permit for developments proposed in areas identified to be potentially at risks from flooding and even landslide.

5.3 Existing Buildings and Infrastructure

- Establish regular monitoring, maintenance and cleaning of existing drains which are located within the vulnerable areas. Monitoring could be carried out by Officers of MCVP who work regularly on sites.
- Consider provision of proper drainage system within inhabited vulnerable areas where drains are absent.

5.4 Tree Planting

- Encourage tree planting to increase sink capacity and promote a carbon-neutral town.
- Promote green spaces which can help in flood control. Provide greenery such as parks and green open spaces and planting along roads and around development.
- Develop a policy to replace the cutting of one tree by the plantation of five trees where applicable.

5.5 Agriculture

- Plant trees around fields to prevent flooding and soil erosion.
- Encourage farmers to plant a variety of heat and drought resistant crops. Also a variety of crops will reduce the risks of crop failure.
- Promote rainwater harvesting for irrigation and to adapt to the risk of interruption in water supply.

5.6 Awareness raising and sensitisation

- The MCVP to consider carrying awareness campaigns to disseminate information regarding vulnerable areas to its citizens, in view to enable them to take necessary precautions. Awareness media could include the following:

  - ✓ Meetings and organisation of talks with different target groups such as women community, youth, students and the public in general.
  - ✓ Distribution of Pamplets/Flyers giving information to citizens on the vulnerable zones and actions to be taken.
  - ✓ Engage key representatives of vulnerable localities, including community leaders, leaders of 'Force Vives' so that they take the messages back to the inabitants of their localities.
  - ✓ Publish information regarding the vulnerable zones and actions to be taken on MCVP website.
  - ✓ Key messages could be displayed on the digital display screen available at MCVP.

- The MCVP to also consider carrying awareness campaigns to prevent citizens from throwing wastes into water passages, and promote the concept of waste segregation, composting and recycling.

5.7 Strengthening the functioning of the Council and Capacity Building

- Allocate additional funds for the maintenance of drainage systems.
- Increase the number of staff for an efficient and constant on site monitoring system.
- Build capacity of staff on climate change, extreme event preparedness, vulnerability assessment and use of vulnerability maps for efficient delivery of services.
- Develop an evacuation plan and strategy for people living in the vulnerable areas.

6.0 Development of an Action Plan

The MCVP will need to develop yearly action plans for the activities to be undertaken with the identified vulnerable zone. Each action should be accompanied by a priority, estimated time for implementation/completion, staff allocation and list of necessary resources (financial, tools, external support, etc.). It should be ensured that the actions are properly assigned and can be implemented.

An example of an action plan is given in Table 5 below. The MCVP to consider customizing same.

The MCVP to communicate the approved adaptation action plan to staff to ensure commitment across council.

Table 7: *Example of an action plan*

		Year											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Assessment of vulnerable sites		▬▬▬▬▬										
2	Maintenance of drains in vulnerable sites	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬											
3	Construction of new drains			▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬									
4	Updating of GIS data	**MCVP relies on the collaboration of other stakeholders.**											

7.0 Implementation, Monitoring and Evaluation

Following the approval of the adaptation action plan, MCVP to carefully consider timely award of contract so that implementation of all scheduled activities are as per proposed time frame.

During the middle of the year, an assessment of works performed should be carried out as a means of evaluation.

8.0 Conclusion

The tools included in this toolkit have been developed by MOESD with the close collaboration of the MCVP. It includes information, data and maps regarding the sites which could be vulnerable to climate change in the areas falling under the jurisdiction of the MCVP. A commitment by the council to circulate this document to its relevant staff for using this toolkit is encouraged. Any questions regarding the content of this toolkit and the tools within it should be directed to the Director of Environment (dirdoe@mail.gov.mu).

9.0 References

1. Department of Climate Change, Australian Government, (2008), *ICLEI Oceania: Local Government Climate Change Adaptation Toolkit.*

2. Department of Climate Change and Energy Efficiency, Australian Government, (2010), *Climate Change Adaptation Actions for Local Government.*

3. Ministry of Environment and Sustainable Development, (2013), *DRR Strategic Framework and Action Plan.*

4. Mauritius Meteorological Services, (2009), *Climate Change Impacts on Mauritius.*

5. Mauritius Meteorological Services, (2010), *Second National Communication for Mauritius.*

Steps to be followed by MCVP Staff for working with the Vulnerability Assessment Data in the Geographical Information System

1.0 Introduction

The user friendly Quantum GIS (QGIS) software is used as part of this toolkit, as it is free and provides all the necessary functionalities for the purpose of this toolkit. QGIS is licensed under the GNU General Public License. The GNU General Public License guarantees that the software remains free for all its users and also guarantees the user's freedom to share the software.

QGIS offers many of the common GIS features and utilities necessary to view and edit data and to generate a map: zooming, map scale, legend panel, layer appearances (colors, symbols, etc.), thematic mapping, labelling, and measuring (including area), and more:

- Readily works with data in multiple formats
- View and query attribute tables (database)
- Conduct spatial queries
- Create new layer
- Edit, delete layer
- Generate maps
- Print, and export maps
- Free useful plugins providing other important GIS functionalities are available online.

The Free and Open Source QGIS software version is QGIS 2.0.1 released in September 2013 is provided in the CD which forms part of this toolkit. The software is located within the folder 'QGIS Software'.

The software can also be downloaded from the Quantum GIS website, at http://www.qgis.org/en/site/forusers/download.html

The QGIS website will open as shown in the image below:
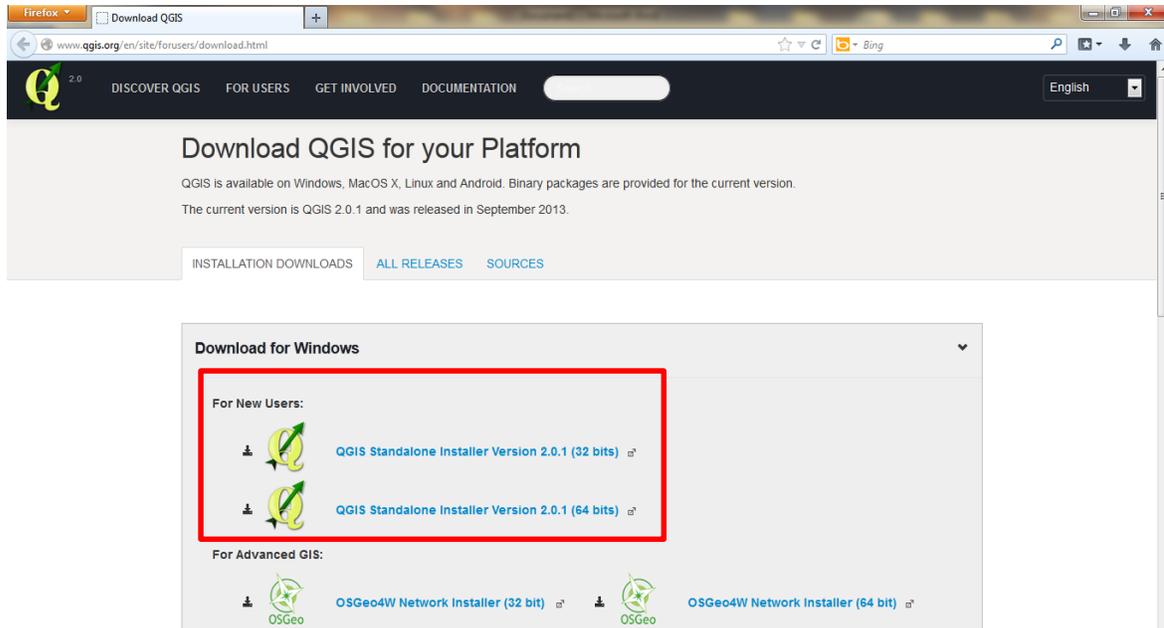
To download the QGIS software, click on the link *'QGIS Standalone installer Version 2.0.1 (32 bits)'* within the red rectangle or on the link *'QGIS Standalone installer Version 2.0.1 (64 bits)'*, depending on the type of your computer/laptop, whether it is 32 bits or 64 bits.

2.0 Installation of the software

After the software has been downloaded, double click on the QGIS-OSGeo4W-2.0.1 icon as shown in the image below:

The wizard shown in the image hereunder will open and will guide you through the installation of the software:
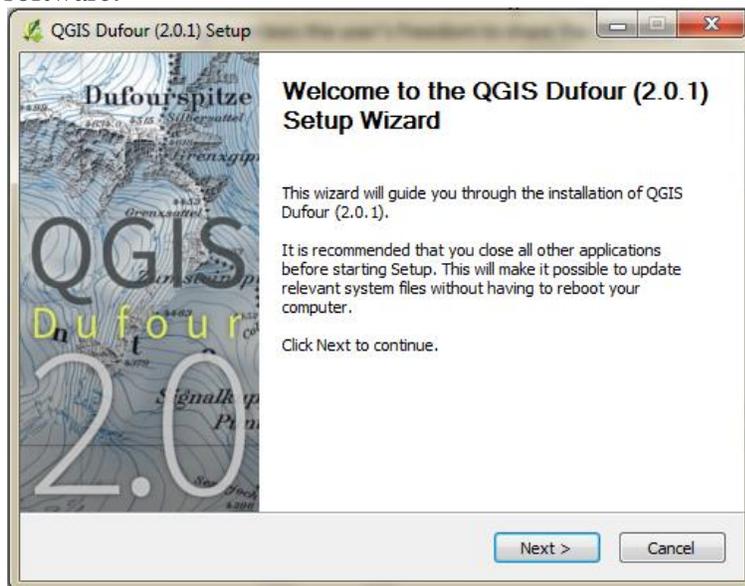
Click the 'Next' button to continue.
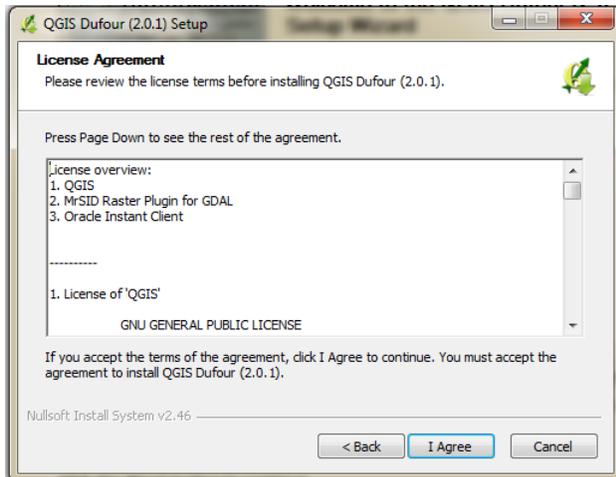
Click on the 'I Agree' button to continue.
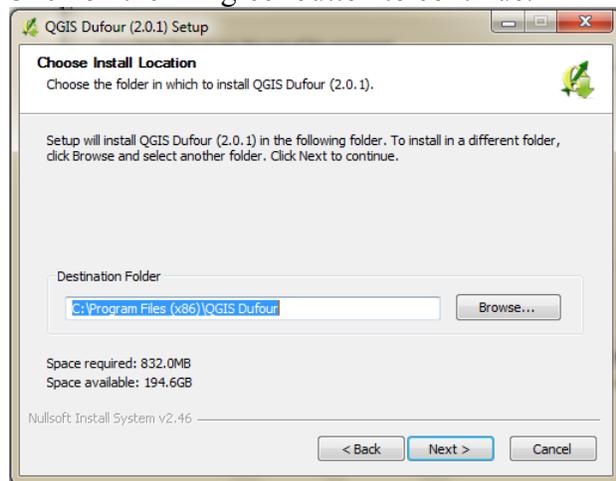
Click the 'Next' button to continue.
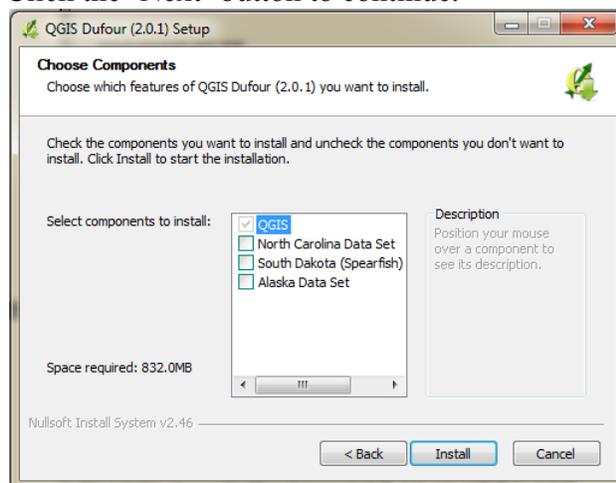
Click on the 'Install' button to finish installation.
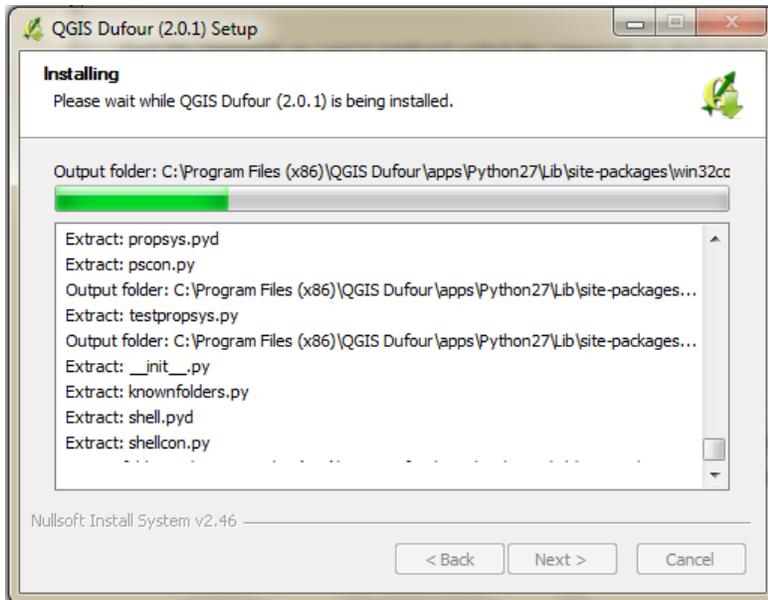
The installation process will take about 3 minutes, depending on your computer/laptop.
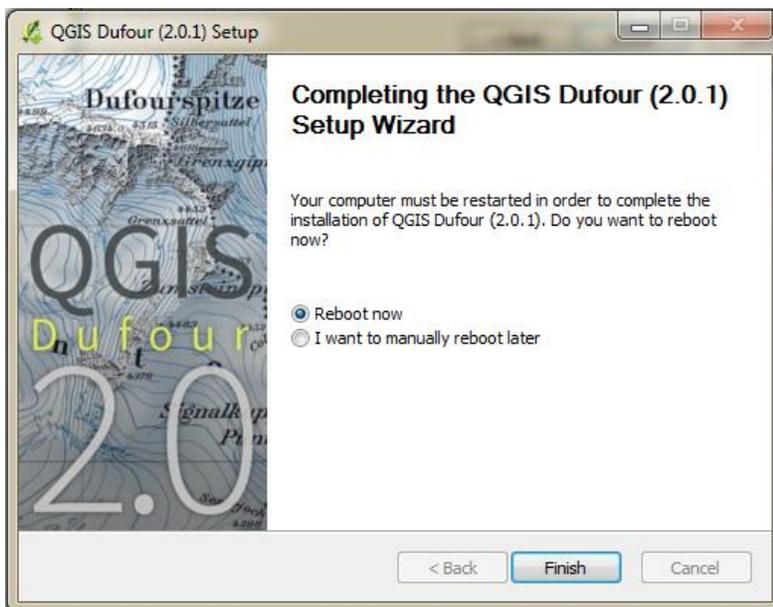
When the installation ends, click on the 'Finish' button. **HOWEVER PLEASE ENSURE THAT YOU HAVE SAVED ALL YOUR OTHER OPENED DOCUMENTS, IF ANY, AS YOUR COMPUTER/LAPTOP WILL REBOOT/RESTART.**

After installation of the software, a QGIS icon will appear on your Desktop.

3.0 Datasets

- **Data paths/folders**

The GIS data for use by MCVP has been provided in the folder 'GIS Data' folder in the CD attached to this toolkit. It is important to put the MCVP GIS data at a location on your computer disk, so that you can access them easily whenever needed. There are different folders within 'GIS Data' folder. Make sure you use the data from the correct folder.

- **Data sources**

The GIS data provided contains data from the following sources:

(i)   DRR project (2013), from MOESD

(ii)   MCVP boundary and annotations, from MCVP

(iii)   Water path data generated by using GIS and Digital Elevation Model

The GIS data have already been saved to their relative paths. This means the main folder can be copied to any computer where the Quantum GIS 2.0.1 has been installed.

For opening the MCVP all the data at once, go to the folder *'GIS Data>Vacoas_GIS_Data_Final'* and double click on the MCVP_CC_Vulnerability.qgs within the folder. The MCVP data will open as given in the image below.
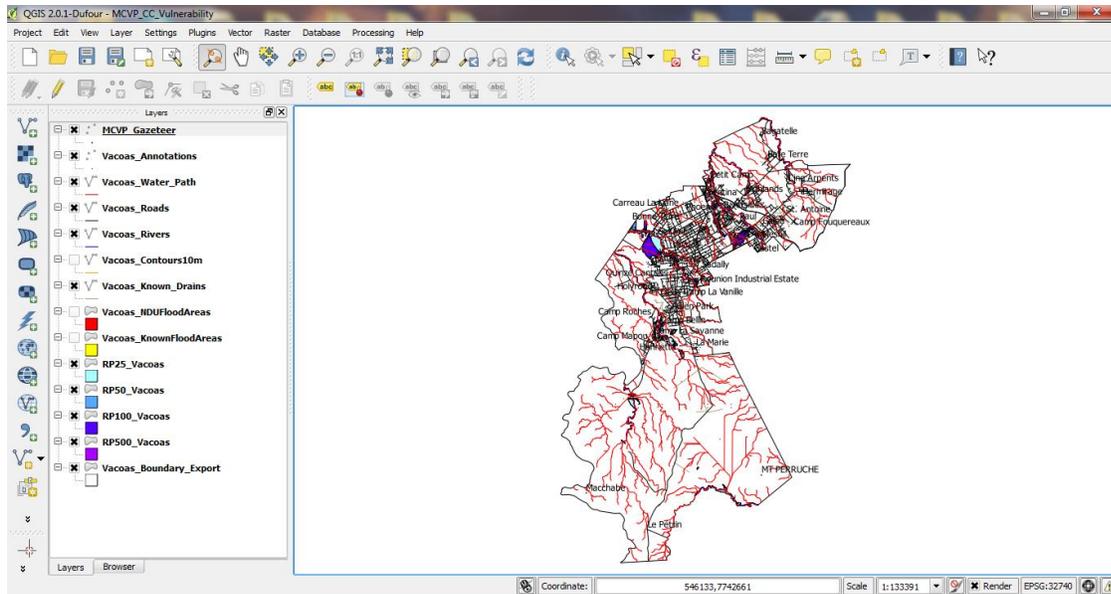
4.0 Basic GIS operations in QGIS

In GIS there are two types of layers: vector layers and raster layers.

Vector data provide a way to represent real world features within the GIS environment. A feature is anything you can see on the landscape such as houses, roads, trees, rivers, and so on. Each one of these things would be a feature when we represent them in a GIS Application. Vector layers could be shapefiles made up of points, lines (polylines) or polygons. For example, in a point shapefile, the points may represent the locations of a locality. In a polylines shapefile, the lines may represent the roads. In a polygon shapefile, the polygons may represent the areas prone to flooding.

Raster layers are images (e.g. satellite images or aerial images or your scanned site map).

4.1 Ordering of layers in the table of content

When opening a file, all the layers will appear in the table of content. An example is given in the image below.

Make sure that you move the layers in the table of contents with the mouse in such a way that the point layers appear over the polyline layers and the polyline layers appear over the polygon layers. This is important, in view to make all the layers visible and to avoid one layer hiding another layer.
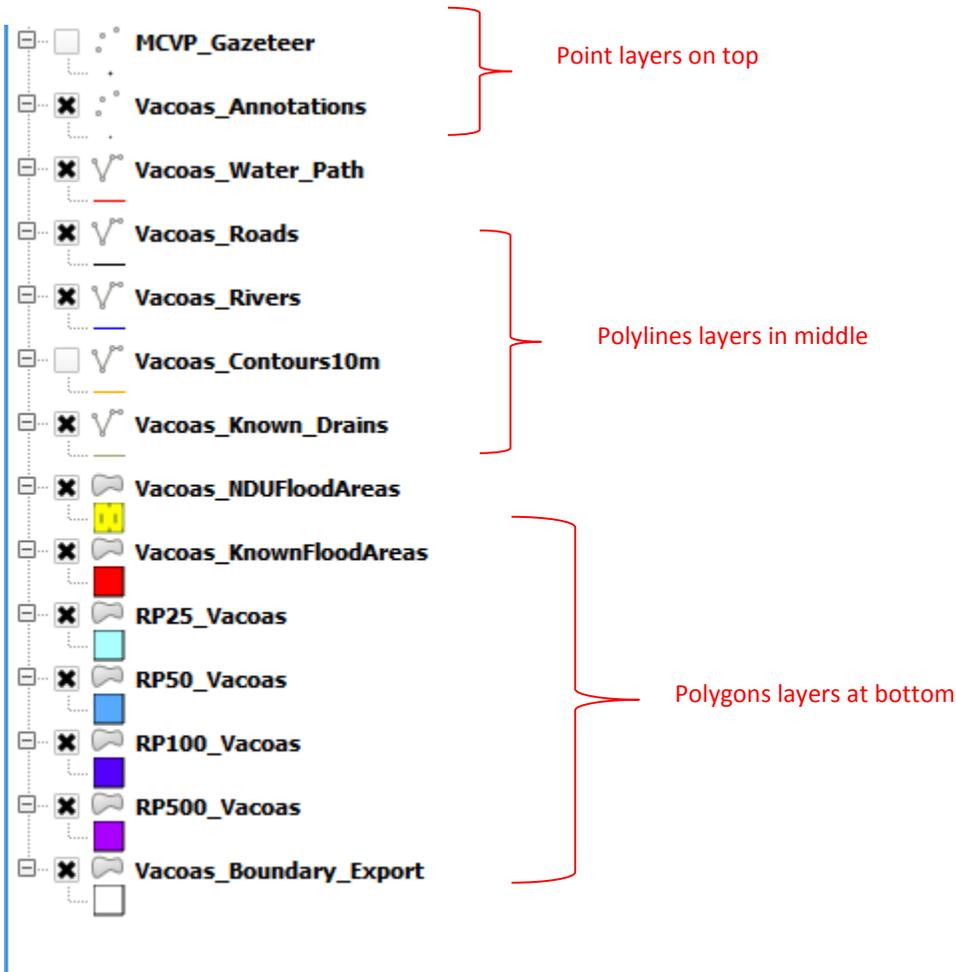
In one mapping project, you might have 15 layers in a map to complete the project goals. When you do not need to work with all of them at one time, you can simply turn off the layers so that you can focus on two or three. If you need to see all the layers together, you can easily turn them back on.

- In the table of contents, uncheck the boxes next to Vacoas NDUFloodAreas, Vacoas KnownFloodAreas, RP25_Vacoas, RP50_Vacoas, RP100_Vacoas and RP500_Vacoas to turn these layers off.
These layers are not visible in the map display.

- Keep the Vacoas_Boundary on and turn all the other layers off.

  Only the Vacoas_Boundary layer is visible now. It contains Vacoas Boundary features that are represented as a polygon.

4.2 Symbolize a layer

Making map in GIS is dynamic. You may wish to change the color of a layer by clicking on the coloured square just below the 'RP25_Vacoas' layer (shown by the red arrow) in the table of content.
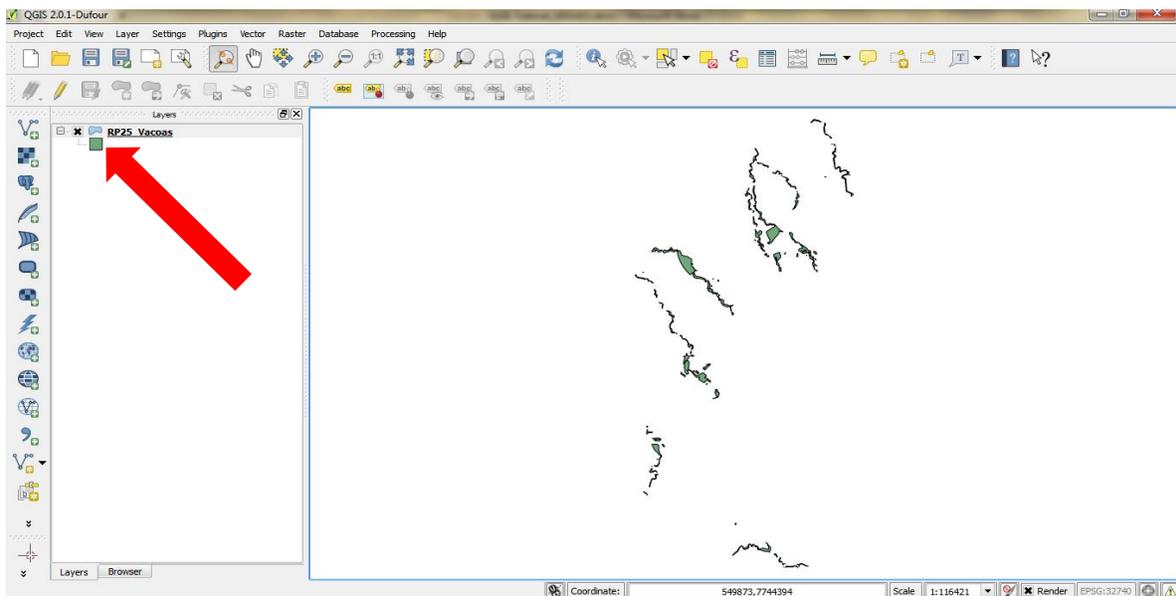
Click on the location shown by the red arrow in the above image. The following 'Select Color' dialog box will open, from which you may wish to choose another colour to represent your layer.
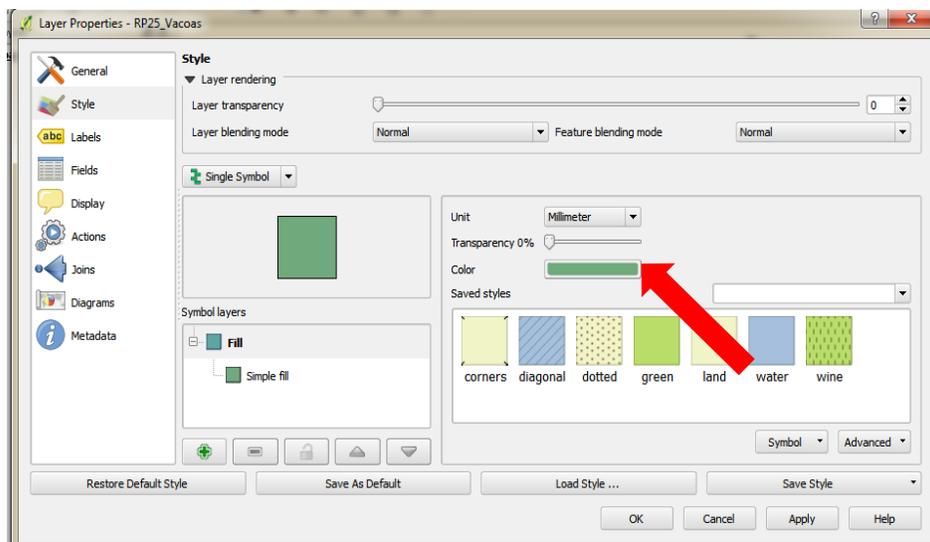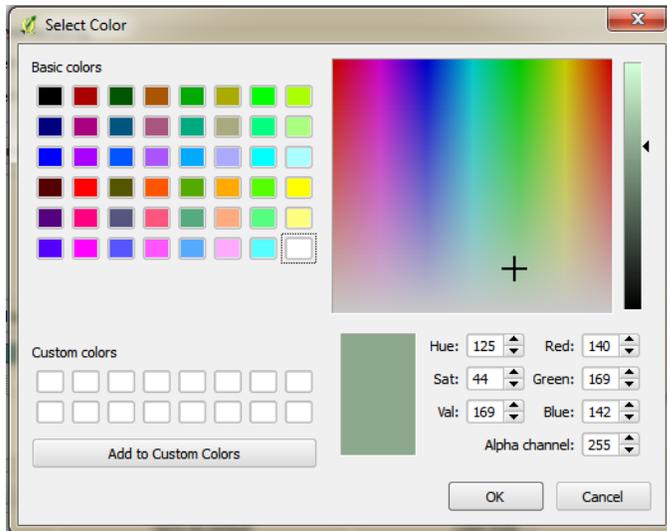
4.3 Use zoom and pan tools

The user can use the Zoom tool , the zoom out tool as well as the pan tool can be used to display the map properly in QGIS.

ZOOM tool: With the ZOOM tool active, both click and drag a box shape over an area of the map. Letting go of the click button will zoom into the extent of the selection.

ZOOM OUT tool: Click any spot on the map view and the view will zoom out, centered on the selected point.

PAN tool: Move the hand-shaped cursor over the MAP view, then click and drag to PAN the map. Letting go of the click button will set the MAP view the new position.

4.4 Labeling features

The label tab on the Layer Properties dialog box lets you label features. Tick the box as shown by the red arrow in the diagram below. You can now label your layer with any one of its features. You can also change the font, size colour and style.
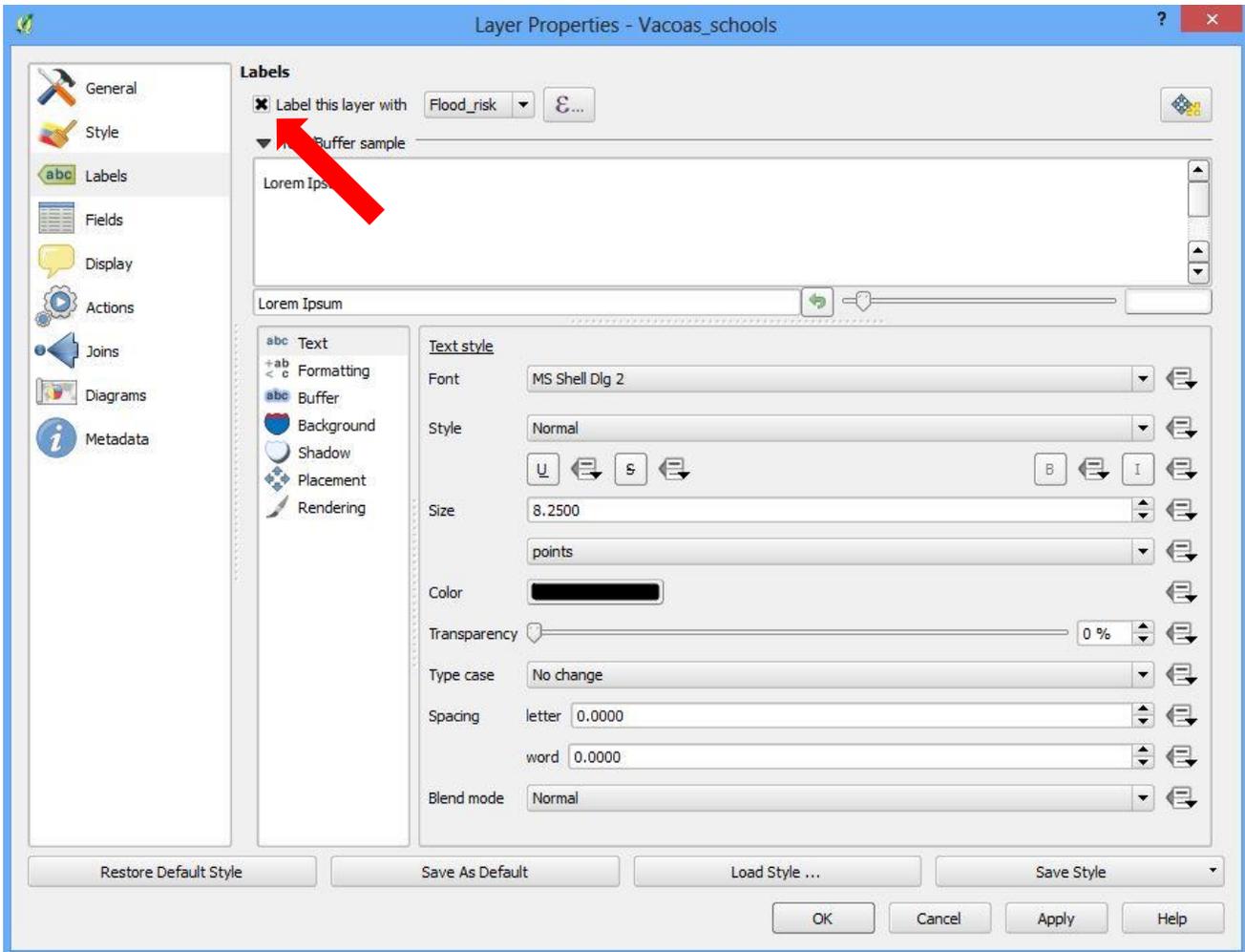
4.5 Identify features

The user can get more information about a layer by using the Identify Features tool . Choose a layer, and then click on the tool icon on the Tools toolbar. Click on any feature in the map display, a window will open showing different information about the layer.
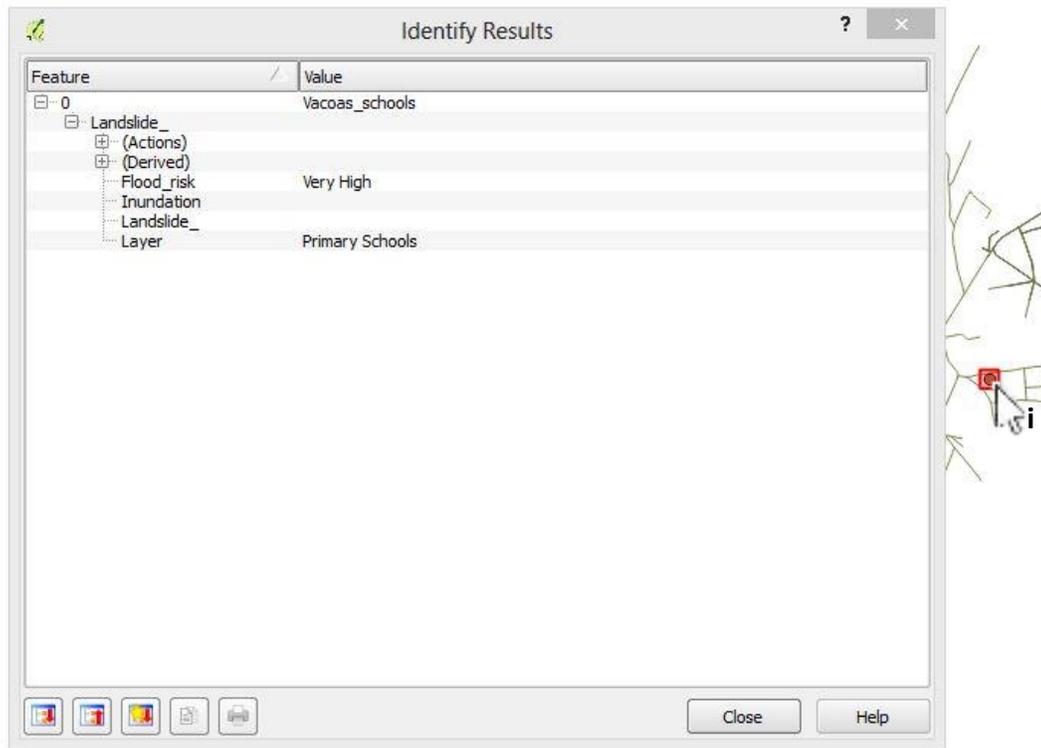
5.0 Creating a new map and addition of layers

Double click on the QGIS icon [QGIS Desktop 2.0.1] on your Desktop.

Close the 'QGIS Tips' dialog box.

5.1 Addition of a vector layer to QGIS:

The example given below shows how the DRR flood layer for the return period 25 years (RP25) can be added to QGIS.

(i)   Click on the 'Add vector layer' [icon] icon indicated by the red arrow.
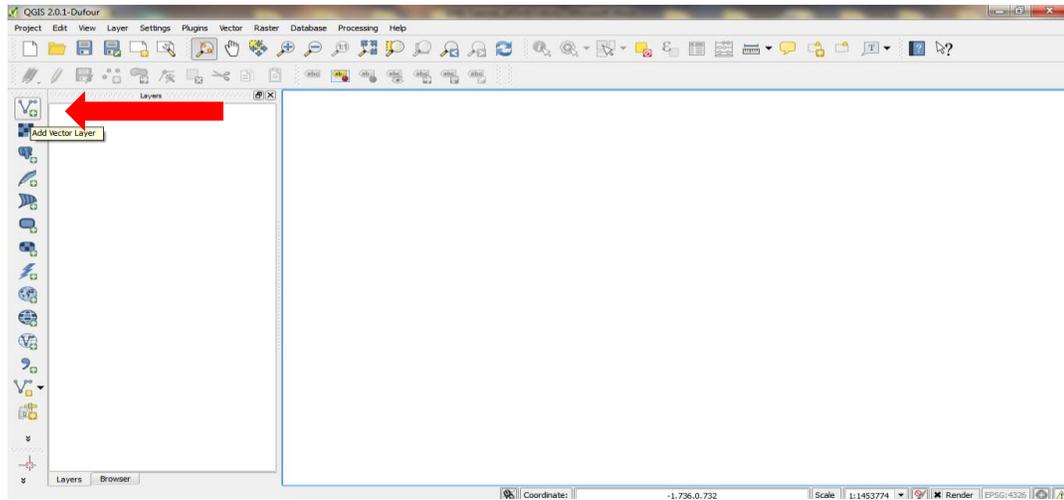
(ii)   The following dialog box will open.
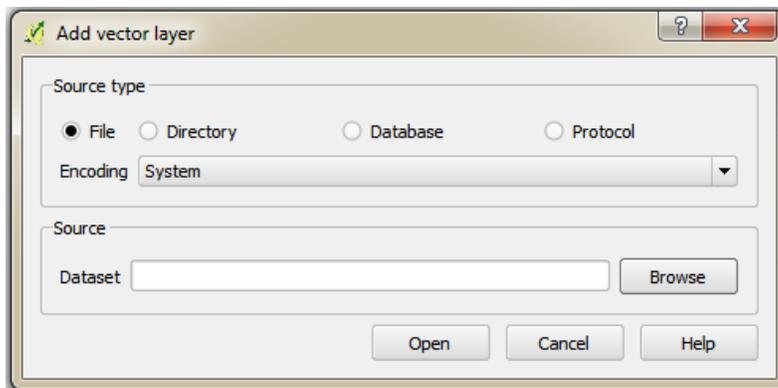
(iii)   Click on the browse button on the above dialog box. The following dialog box will open. Browse to the location of the 'RP25_Vacoas.shp' file on your computer/laptop and double click on it.
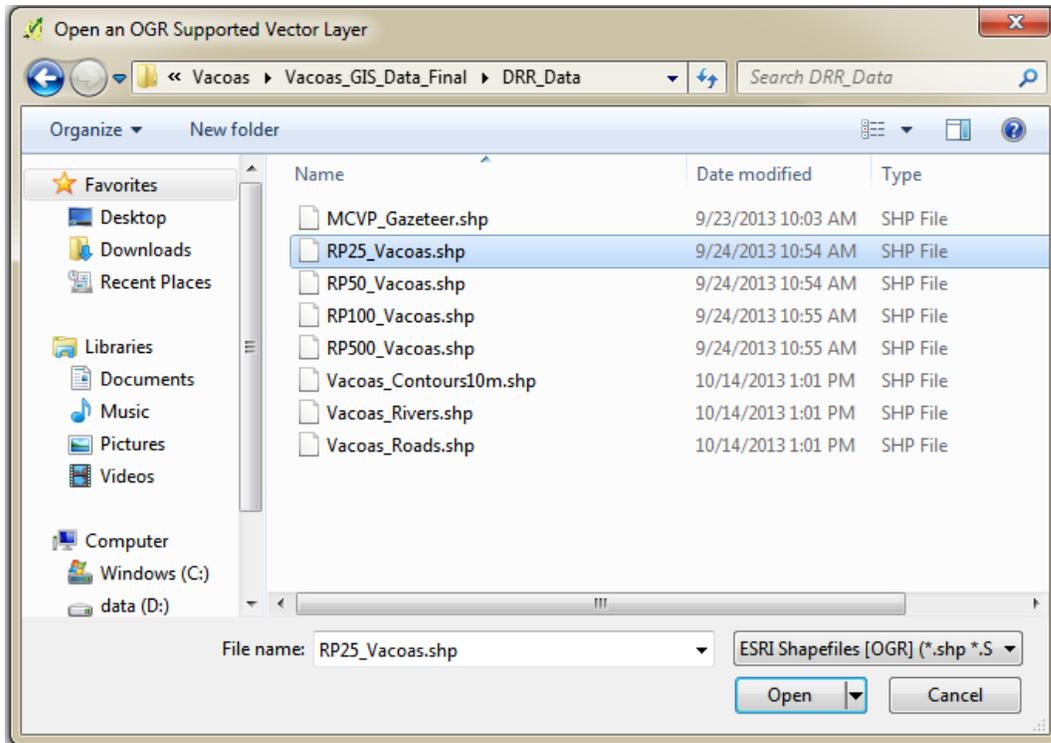
(iv)   This will return to the original 'Add vector layer' dialog box as shown in the image below.
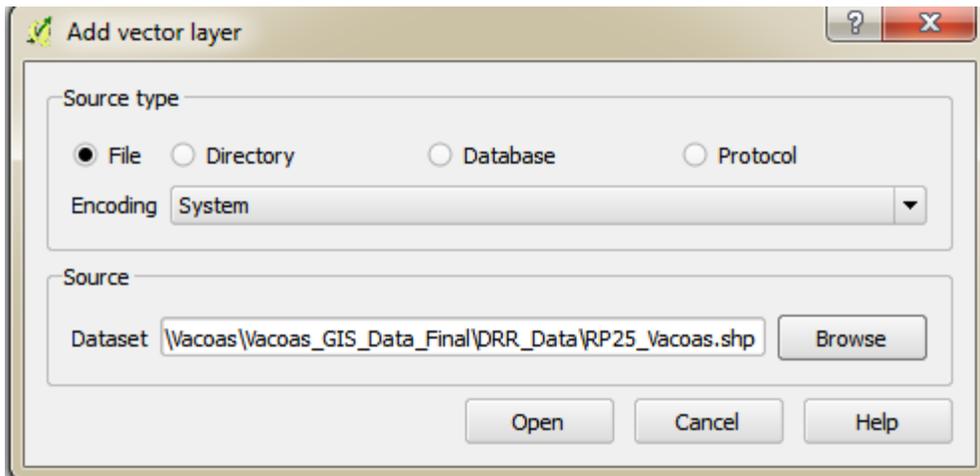
(v)   Click the 'Open' button. The 'RP25_Vacoas' layer will open in QGIS as shown below.
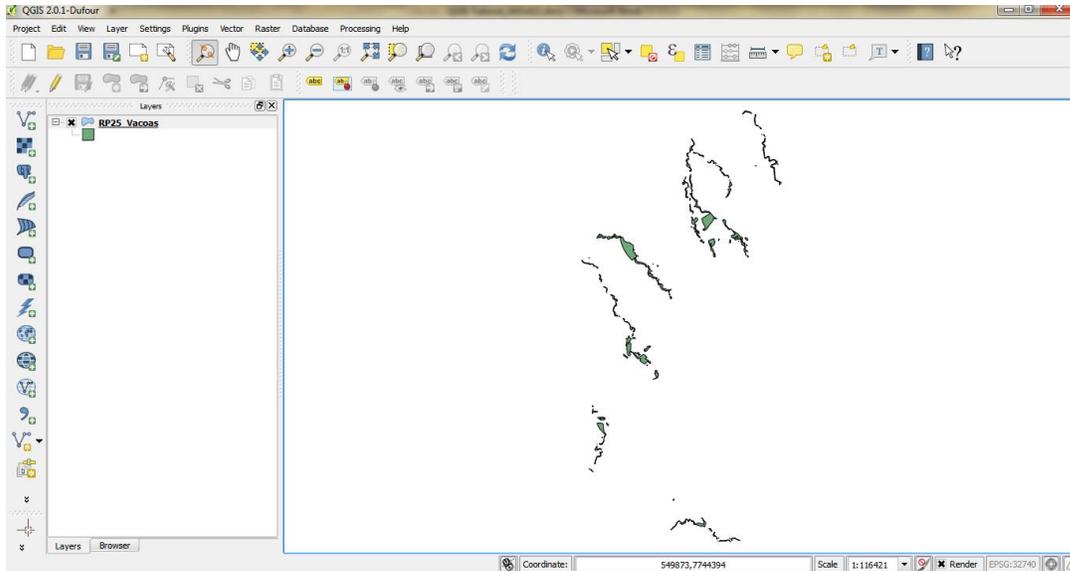
5.2 Addition of a raster layer to QGIS:

Click on the 'Add raster layer' icon and when the dialog box open, browse to the relevant image to open.

Coordinates Systems and Projections

The data provided in this toolkit have already been saved to the 'WGS 84 / UTM zone 40S' projection. Whenever you want to start a new project in QGIS, make sure you add at least a vector layer form the CD provided first (e.g. layer 'Vacoas_Boundary_Export'). The coordinates system of QGIS will automatically be set to the coordinate systems of the first layer added.

5.3 Saving your map

Click on the icon to save your map to the desired path.

6.0 Updating the GIS data

It is important to update the GIS data. For example, the MCVP may identify new flooding area and add same to the GIS. The steps given below shows how to add a new GIS polygon to represent a new flooding site.

Click on the 'Layer' menu in QGIS and click on 'New Shapefile Layer' as shown in the image below.
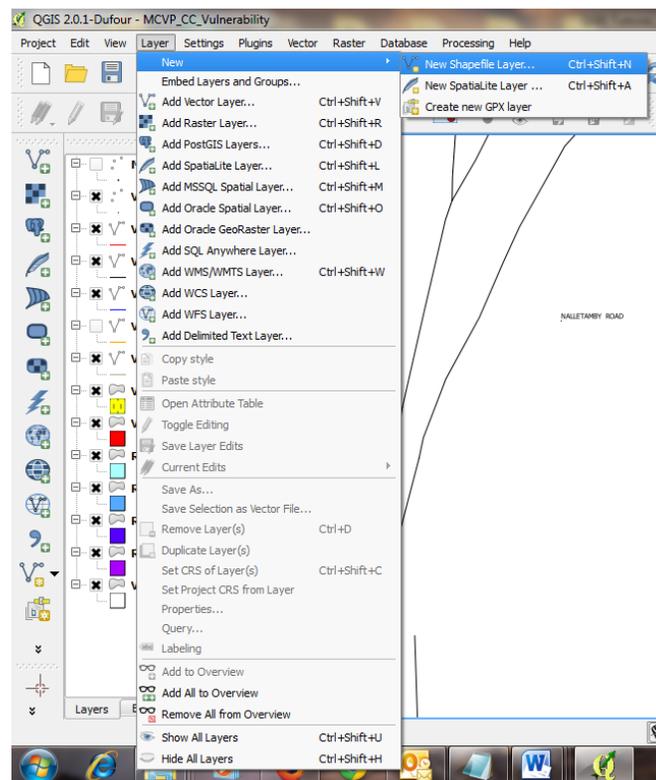
The following dialog box will open. Click on the button 'Specify CRS'.
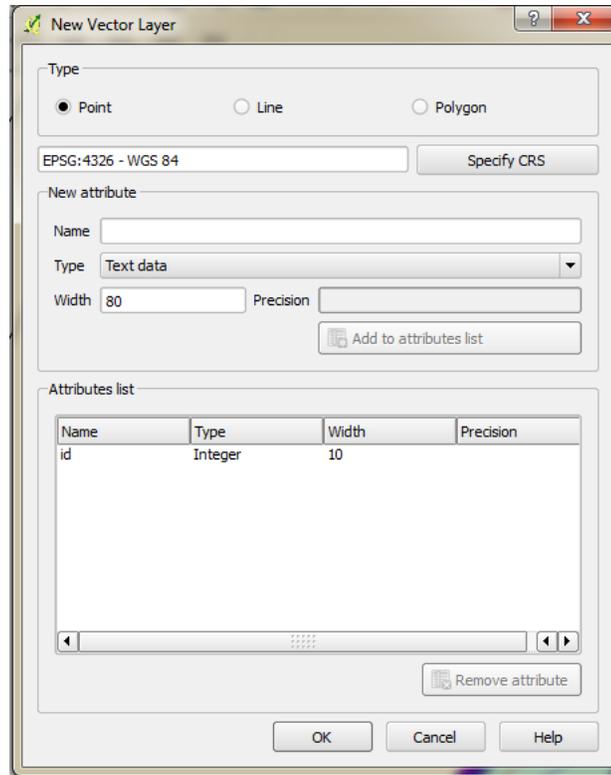
When the CRS (Coordinate Reference System Selector) dialog box appears as shown hereunder, go to the 'Coordinates reference systems of the world' and choose the projection WGS84/UTM zone 40S (EPSG:32740) and click on the OK button.
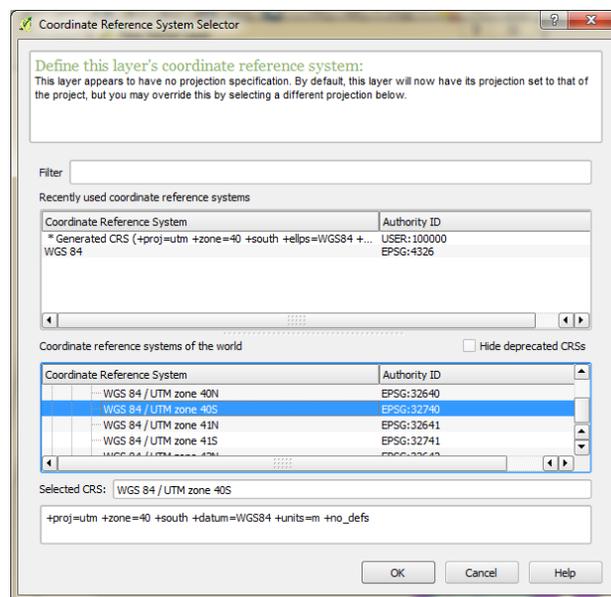
The new projection will be entered into the dialog box shown below.
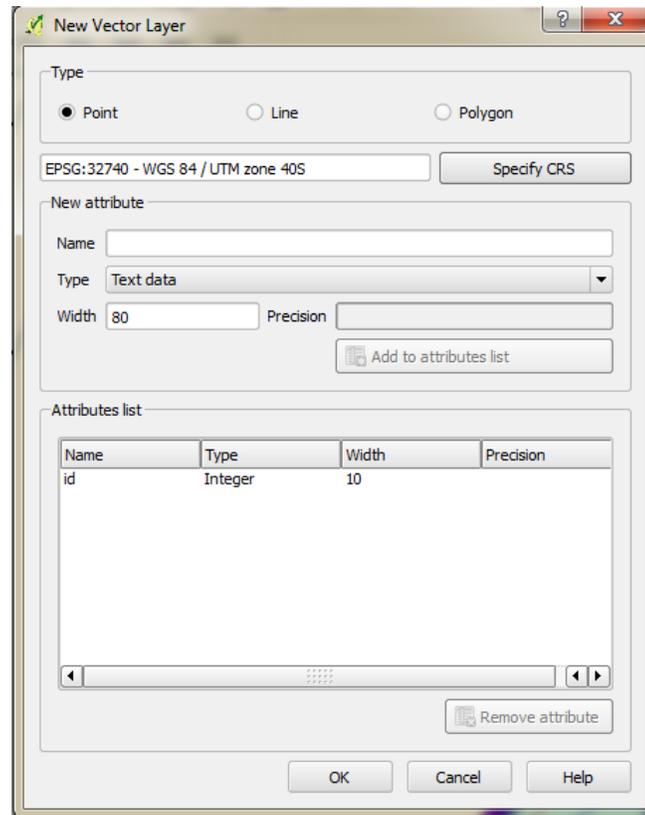
Click on the radio button 'Polygon' at the top of the dialog box shown below and click on the OK button.
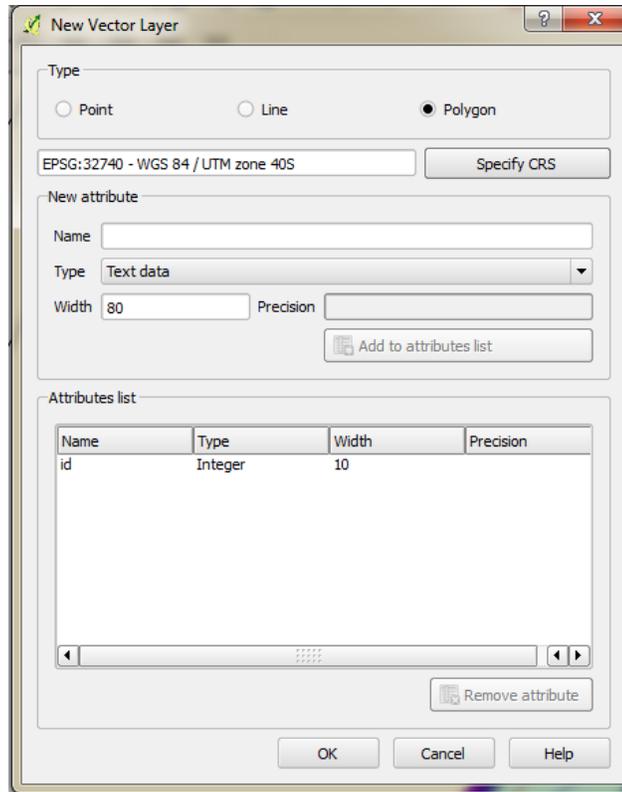
Choose the appropriate folder where you want to save the new GIS polygon shapefile as shown highlighted below.
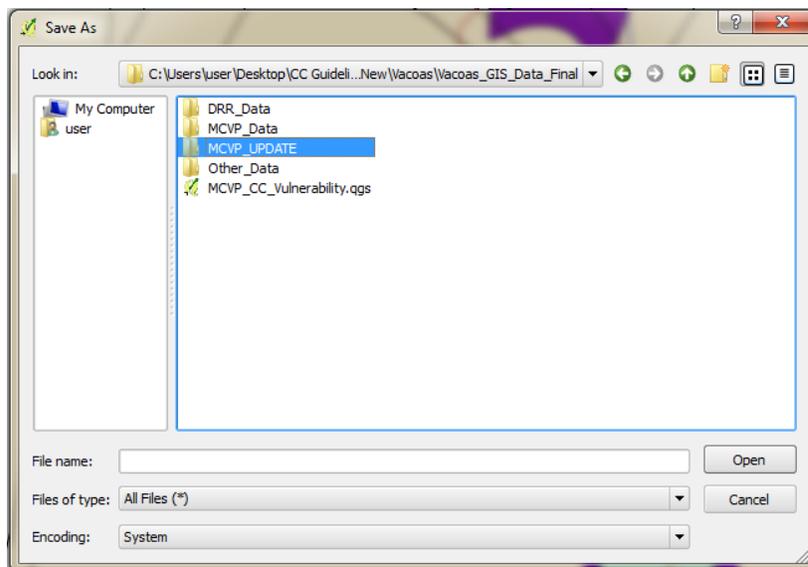
Write the name of your new shapefile and click the 'Save' button.
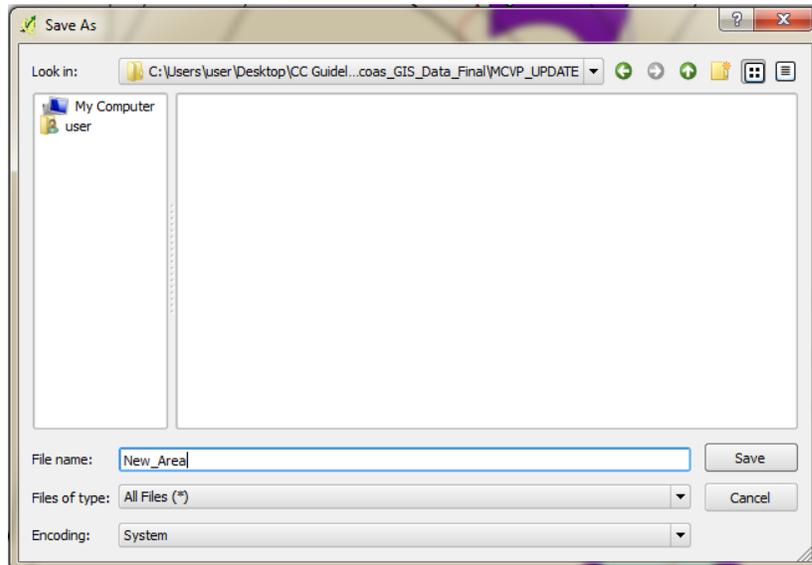
Your new shapefile will appear in the QGIS Table of Contents as shown in the image that follows.
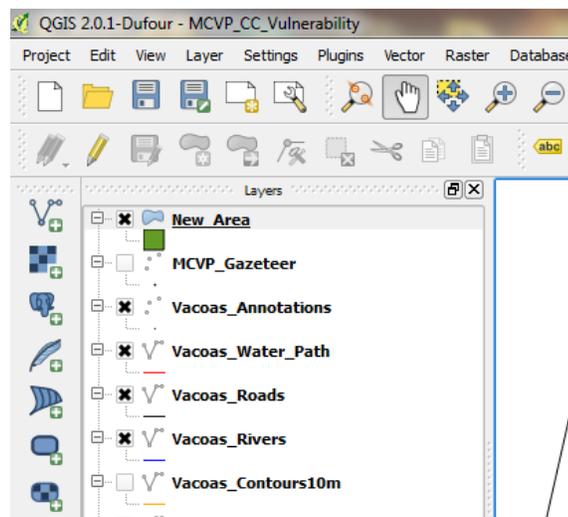
Right click on the new shapefile and click on 'Toggle Editing' as shown highlighted in the image below.
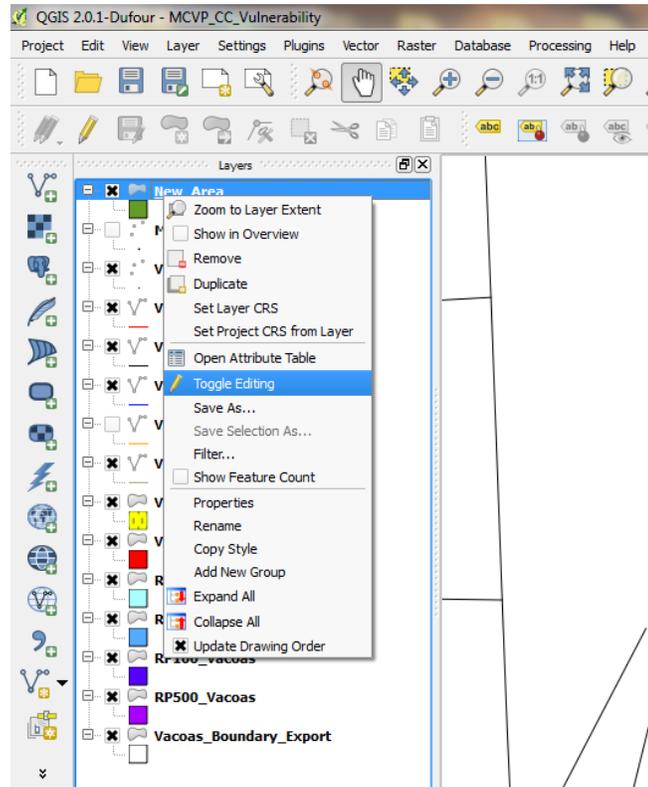
Click on the Add Feature icon as shown by the red arrow in the image hereunder.
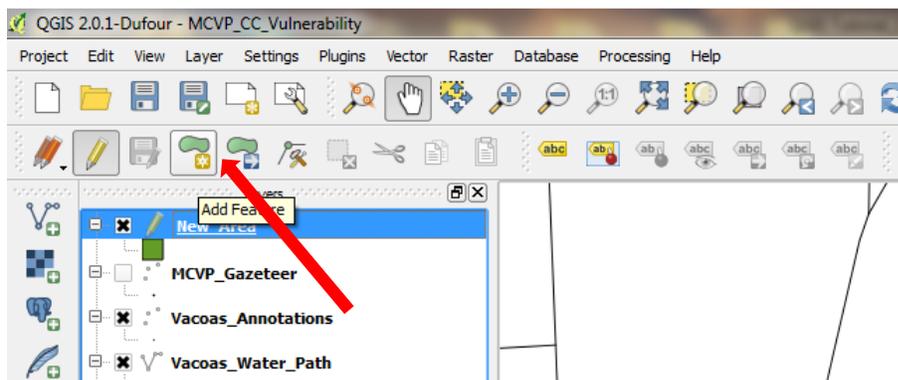
Click on the location where you have identified your new flooding area and the mouse cursor will look like this image:

Start your digitization by moving and clicking on the boundary of the new flood area. As an example you will get a new shape as shown red hereunder:
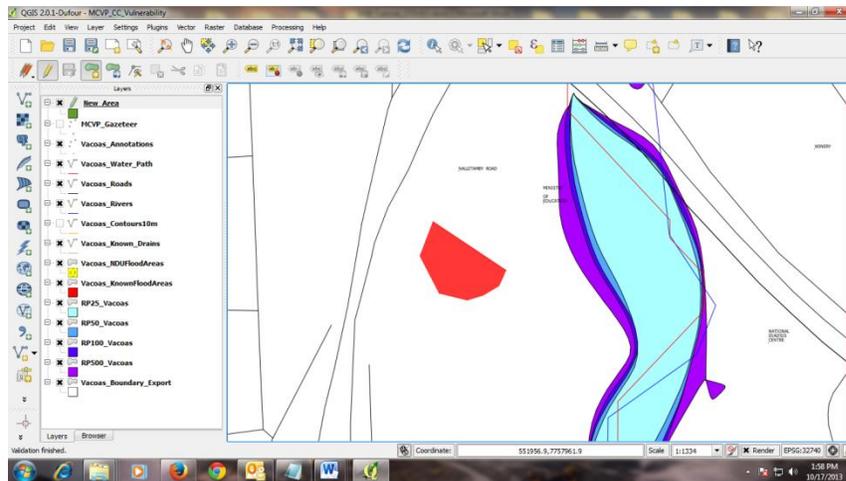
Saving maps as images

From the Project menu click on the sub-menu item 'Save as Image…' and chose the path where you want to save the map image.
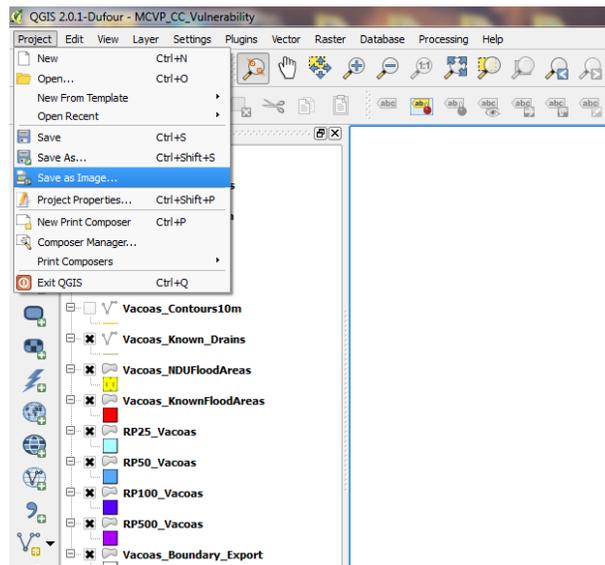
Paste your image in the relevant document.

7.0 Locating a development in GIS

For ease of understanding, it is sometime better to have a layer map onto aerial photos such as those provided by Google Earth. To be able to do this operation, first you have to convert your layer to a keyhole markup language (KML) format.

Converting layer from .shp to .kml

- Open the DRR flood layer for the return period 25 years (RP25) as shown before.
- Right click on the layer.
- Click on save as, the following dialog box will open:
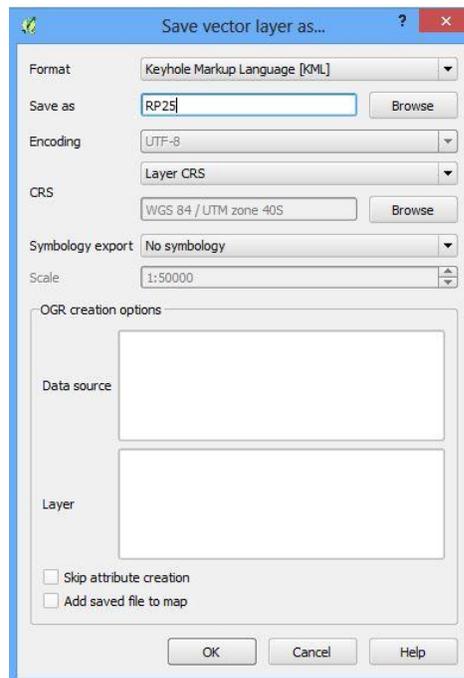
- Name your file and save it in an appropriate folder, then click ok. In this example it will be saved as RP25.kml
- Next open Google Earth.
- Click file and open the file RP25.kml. The layer will be superimposed on the google earth map.

- Right click on the layer in google earth. Click on properties. The following dialog box will open.
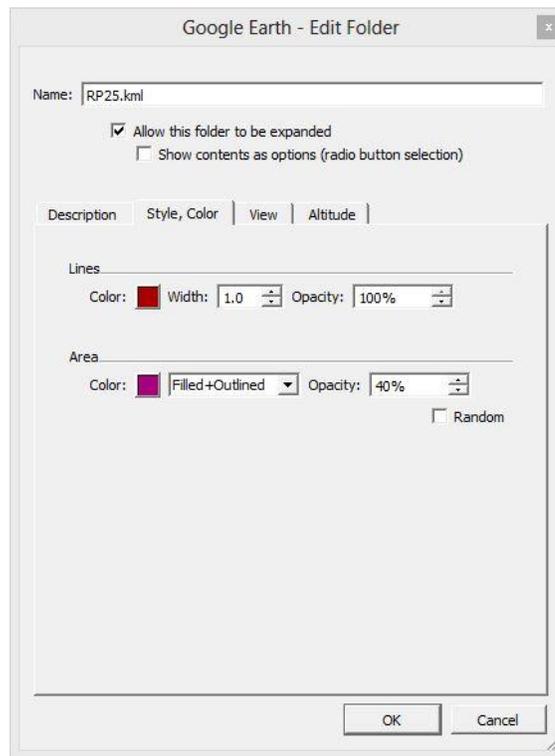
- Click on 'style, color' tab to adjust the colour of the outline and that of the area as well as the opacity of the layer.
- You can then save the map as a jpeg.

- Importing layers in google earth allow you to locate if any specific development is within a risk area.