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Mobile Application on Road Condition Awareness and Routing for Calamities using Adaptive System

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Climate change and calamities has been causing problems and on the roads of the province of Albay. This led to hazardous and damaged roads that presents risks in the safety of the drivers and passengers in the province. The province faces recurring challenges arising from extreme weather events, volcanic eruptions, seismic activities, and coastal hazards, all of which severely impact its transportation infrastructure. As climate change accelerates, the frequency and intensity of these environmental disturbances are on the rise, posing significant risks to the accessibility, safety, and resilience of Albay's road networks. The province's vulnerability to these phenomena necessitates proactive and adaptive measures to mitigate their adverse effects and ensure the continuity of vital transportation services. Road condition rerouting systems play a pivotal role in ensuring efficient transportation networks, particularly in regions prone to environmental disruptions and infrastructural challenges like Albay Province. This research paper presents a development of a conceptual mobile application aimed for travelling awareness of drivers and passengers specifically tailored for Albay Province. The development of the application integrates adaptive systems conceptual framework to provide adaptability of the system in different calamity and climate change scenarios. The research identified the map plans of the road and routes, calamities, and the types of vehicles, and application program interface mainly the Google Map API and Weather Ambee as key points used in the development of the mobile application. The designed road condition awareness and routing for calamities mobile application provided awareness that assisted in identifying safe routes to travel in between municipalities in the province of Albay.

Keywords: Climate Change, Road Routing, Adaptive System, Mobile Application.

1. Introduction

Climate change and calamities are a common problem that poses dangers and risks to the drivers in the roads of the province of Albay in the Bicol Region of the Philippines. These dangers, namely droughts, floods, storms, earthquakes, landslides, volcanic activities are natural calamities created from weather changes and natural phenomenon that are found in the region. Transportation is the lifeline of any region, connecting communities, facilitating trade,

and enabling access to essential services. However, with the presence of the active volcano known as the Mayon Volcano and the recent changes of unusual weather, the disruption of road services affects the driver's safety and livelihood of the communities in the province. A study of Naz, Malonzo, Salvador and Daep discusses the vulnerability of disasters in the province. According to their study the province's geographical location has a high vulnerability of being targeted by numerous disasters in the country. Due to this the imposition of numerous disaster risk management has been implemented to target a zero-casualty goal that is continuing till today. Through the geographic location of province located in between bodies of water and with the presence of the volcano in the pacific ring of fire, it is a major target for disasters that led to the cause of destruction to road infrastructure [1]. Another study by Bautista et al, presents the lahar or volcanic mudflows that are created by typhoons by mixing volcanic matter and floods that posed destruction on numerous communities and road infrastructures in the province. This led to the need to reshape and repair road infrastructures that imposes difficulty and safety risks for drivers as it created damaged and rugged roads, blocked roads or dead ends, potholes, and even rerouting for finding safe roads [2]. Countless communities in different municipalities livelihood are facing difficulty in transportation due to the areas in the province are interconnected with numerous roads surrounding the volcano but faced vulnerability and damages in calamities brought by climate change and natural disasters. In the study of Buot, community wellbeing in the province that are affected by the calamities provides data that helps the government provide disaster risk measures [3]. The disaster risk measures provide the ability to divert possible dangerous outcomes on upcoming disasters from known or unknown calamities. This disaster risk provides ideas to develop a system that has the adaptability to provide counter measures. In the risk of drivers in the event of a disaster, the system can provide the driver the awareness and predictability to assist them in traveling to roads that can be risky. A study by Martinez-Villegas et al, analyzes the factors that help people in the province overcome disasters [4]. It pertains to the experience of the people in the communities that faced countless disasters provides better assumptions and decision-making skills in dealing with risks and finding ways on survival and evacuation for safety. It suggests that experienced drivers in the areas can provide knowledge and data on common roads that are frequently affected by disasters. This data provides the systems adaptability on determining target roads experienced by drivers in the province. Another study by Abante suggests a concept on using risk hotspots to provide valuable data in determining risk problems in each area [5]. This hotspot measures the degree of risks and how the area determines the range of the risk in the event of a disaster in the Albay province. This concept is used to provide the locations and calculate the area of risk effectivity in which can be used on road infrastructures in determining the risks and damages that can be encountered by the drivers. This provides the system on the adaptability on awareness of the measure of damage that can be encountered and provides decision making on rerouting. Additionally, a study by Abante also suggests another solution by determining the road measures of infrastructures constructed to nearby risky locations to provide the road accessibility and services to vehicular transportation [6]. To conduct accessibility of roads the system application needs to define the measurement and the range of the roads on risk areas to determine if the roads are safe and away from disaster risk areas to provide the awareness in an event of a disaster.

Road rerouting, also known as road diversion or detouring, is a process utilized in transportation management to redirect traffic away from a particular route onto an alternative

path. This strategy is typically employed in situations where the regular route is inaccessible or experiencing congestion due to various factors such as construction, accidents, natural disasters, or special events. A study conducted by Darvishan and Lim discussed evacuation rerouting for multiple road disruptions [7]. This provided evacuation network plans for evacuation of communities against calamity disasters. The study follows the concept of rerouting in which it determines the best routes that can be used in each situation. Rerouting includes the range of strategies on determining effective ways on managing the vehicles and advises drivers alternatives roads that can be taken to meet their destination. This also provides the fastest routes that can be taken with the traffic and the road specifications that can suit the vehicle. According to the study of Falek et al, road rerouting is used to provide the efficient and fastest way to the drivers in engaging urban areas and cities [8]. With the integration of real-time traffic analyzation, rerouting can provide the drivers with the view of traffic congestion recommending them by the system to take routes that can take them safely and faster to their destinations. Alternative paths and road selections should be implemented proposing different strategies that can incorporate maximum utilization of the use of roads. On the study of Tseng and Ferng, discusses this concept in utilizing the use of roads by appropriate vehicles [9]. The tackle on traffic congestion promotes the development of different strategies that can be applied to different scenarios. A strategy on rerouting discussed by the study of Kiec, D'agostino and Pazdan proposed a methodology that pertains to maximizing the safety of traffic operations that provided tools that help on the system Intelligent Traffic Control system [10]. It discusses that analyzation by determining safety levels of each road categories can provide more identified routes in concerning rerouting procedures for traffic in urban areas and cities. Another study by Khan, Koubaa and Farman presents scheme for smart routing providing the use of internet of things (IOT) to be applied on vehicles to provide the ability detection and avoidance on the roads [11]. Simulation of their concept study explains the implementation of systems to vehicles allows drivers to have assistance in detection and avoidance of road hazards there by improves the recommendation of road rerouting for safer travel. The study of Chavhan et al, discussed that in metropolitan urban areas numerous factors must be determined to provide alternative routes for drivers [12]. One of these factors includes the accidents that frequently happen and disrupt the drivers. Their study explains that google maps are a vital source for navigation, but it lacks the adaptiveness on sudden occurrences that can happen during the navigation. These sudden occurrences include the weather conditions and disaster risks occurrences like floods, heavy rainfall, storms etc.

The research sought to develop a mobile application with adaptive system for providing road awareness of drivers in the Albay in events of climate change and calamities that can encounter risks of safety for travelling. This application consists of the concept of adaptive system in which it adapts to the changes of the climate and the encountered calamities and provides rerouting roads and pathways that can be used to guide drivers and mitigate risks to reach their destinations.

2. Methodology

The research used data gathering surveys and interviews to identify the requirements to be used for the development of the application. The data collected were the maps data on road

terrains and mapping of routes, weather calamities and disasters, and the vehicles travelling in the province of Albay. The requirements as follows build the features and the adaptive intelligence of the application:

Road Mapping and Terrain of the Albay

The province consists of numerous cities and municipalities that are situated surrounding the areas on the foot of the Mayon volcano. Forested mountainous areas and hills are found in these areas of the municipalities in which roads are present to interconnect places. As shown in fig 1, the map terrain of the Albay province consists of mostly green forested areas that stretch to the edges into the seas. Roads in these areas are found to have smooth and too rough grounds in which vehicles have experienced travelling. The main highway as shown in the map interconnects the municipalities in the area that are mainly used by vehicles to travel. The map identifies the terrain details of the routes and passages in which it shows the type of terrain and elevation of the highway. On fig 2, it shows that each municipality and cities in the province also consist different routes that connects alternative passages and roads to the main highway. The alternative routes are essential used by the drivers of the province as it is used to access inner communities and infrastructures in cities and municipalities. This also provides drivers the alternative approaches such as shortcuts and traffic congestion avoidance to save the time to reach destinations. However, these alternative paths and routes are rarely monitored and maintained that results in damage and hazards that can risk the safety of drivers. In addition, the province faces frequent climate change and calamities in which these roads are one of the primary targets of disasters that places hazardous zones and disrupts the road services. The research used map data to determine the main highway and the interconnected roads in the Albay province. This data allows the application to determine the type of terrain the vehicle is travelling on and apply recommendation of alternative routes and passages that can be used to ease the travel time and the risk of the vehicle's safe capability. It also helps the application determine the target roads and highways that are primary targets of hazardous damage and conditions that the drivers experience in calamities.

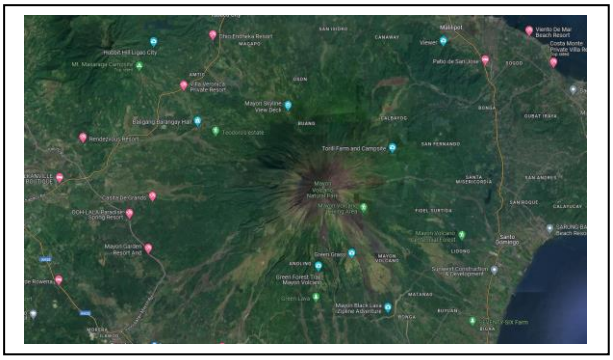

Fig 1. Road Terrain Mapping of Albay Province

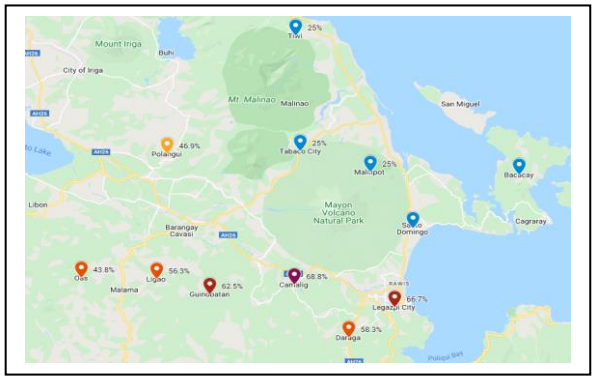

Fig 2. Road Mapping of Albay Province

Calamities and hazards

The research gathered data on the road hazards in the event of calamities and disasters. The identification of this hazard can determine the calamities that frequently occur and affect the roads and highways. Presented gather data on fig 3 displays the top four vital calamities that cause hazards on the roads of the province. These calamities cause aftermath damage that affects the road conditions as well as disrupting the flow of transportation in the province. The most common is typhoons in which drivers encounter numerous debris and wreckage as well as landslides on the roads. The province of Albay is the heart and center of the Bicol region and is widely known areas that are frequently hit by typhoons and hurricanes. Countless damages to road infrastructure are a common occurrence in the aftermath of this calamity and has cost time in repairs and cleaning to restore road conditions for the drivers. Another calamity involves the rainy climate as well as the topography of the province is situated. The province consists of rivers and streams that stretch to the seas on the edge of the region. In the event of heavy rainfalls, floods occur posing risks on submerging roads and highways making blockages which vehicles cannot pass through. Floods are also a common occurrence where they affect the inner routes of cities and municipalities. Adding to this, Lahar is defined as a combination of volcanic material and water that is formed though floods. Lahar flows are a rare occurrence since they involve volcanic activity such as eruptions and floods caused by heavy rains or typhoons. But even so, they pose one of the deadliest calamities that wreaks havoc and destruction on road infrastructure since they are time consuming on cleaning and restoring damage that have caused. Likewise volcanic activities are a rare occurrence but still have a high plausible rate in causing calamities since Mayon volcano is defined as an active volcano that is on the center of the province. The volcano has a history in causing calamities such as eruptions, lava flows, lahar and earthquakes that causes hazards on road conditions of the province.

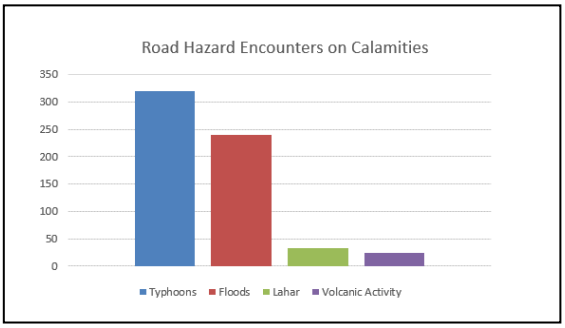

Fig 3. Road Hazard Encounters on Calamities

The seasonal climate of the Philippines consists of only two namely the dry and wet seasons. Data gathered as presented on figure 4 displays that road hazards are frequently encountered in the wet seasons. Calamities are an occurrence mostly during wet seasons in the province and examples of which are typhoons and floods. This indicates that there are higher risks to the driver's safety in navigating in the province through the wet season. In the recent climate change according to the study of Lagman, Albay province is a high-risk zone that involves excessive rain fall that most parts of the region. By this there are higher change in encountering calamities in the wet seasons. On the other hand, the dry season on the province consists of the problem of droughts on high heat index and the occurrence of earthquakes and volcanic activities such as eruptions, ash falls, and lava flows poses risks on the road conditions and the drivers. The development of the application involves this data gathered data on calamities to be used to the adaptability intelligence of the system. Adaptability approach consists of how the system interacts to the recorded possible calamities that may occur and relays safety precautions on road awareness and routing recommendation to the drivers to ensure safety in travelling in the province.

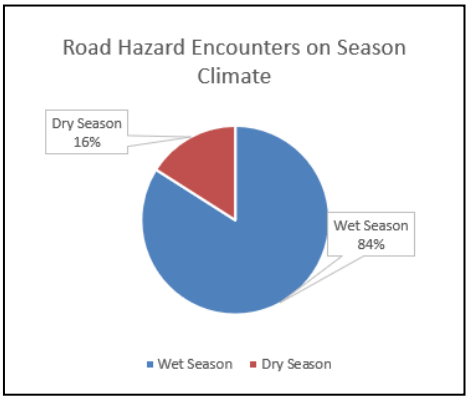

Fig 4. Road Hazard Encounters on Seasonal Climate

Danger Zones

The Danger Zone of the province of Albay is defined as the circular area projected by the disaster risk management council to present a 6-killometer area wide scale that are at risk in an event of volcanic activity of the Mayon Volcano. Known as the 6-kilometer danger zone,

is measured at the crater of the volcano down to the affected areas at the foot of the volcano. As presented in fig 5, the danger zone is presented as a circular heat map that determines the scale of the disaster that can reach. The presence of roads in the areas are to be considered and monitored such that the routes are used to travel in between communities but at the event of volcanic activity, numerous roads are at the range of the danger zone. The roads in this area are found to have challenging terrain such that vehicles have a hard time traveling and can be risky at the occurrence of volcanic activity. The research development of the application of road awareness considers the danger zones as part of the requirements for the adaptability in rerouting for vehicles. This determines the adaptability of the vehicles to maneuver road terrains that can reduce the risk of the safety of the drivers in the event of volcanic activity.

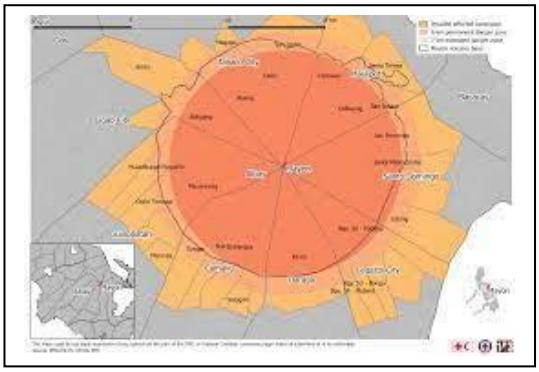

Fig 5-Kilometer Danger Zone of Mayon Volcano

Source: Adapted from [14]

3. Adaptive System Intelligence

The development of the research used the adaptive systems to provide the crucial role in managing and adapting changes of environment to help the drivers of vehicles to safely maneuver roads and reduce the risks of safety at the event of calamities and disasters in the Albay province. Adaptive systems are defined as systems that shift to the changes to suit the flow and progress of the application. The research used the adaptive system to allow the adaptability of the system to shift in the event of changes on seasonal climates and on the occurrence of calamities and disasters that the drivers may encounter on the roads. The framework for the system development used an adaptive system approach to create the features based on the research study of Naz, Palaoag and Red [14]. As seen on fig 6, the diagram shows the flow of the intelligence module of the system application. The module requests the road and vehicle data on the driver. Road scenarios are created using the gathered data by the driver and the map, weather and climate, and the calamity that have occurred. This scenario is then analyzed and compared to other similar scenarios to provide the road condition status for the driver's awareness and the recommended safer and effective routes to take in traveling to a destination in the province. Each of all created road scenarios are archived to be analyzed by the system for future encounters on roads. This also provides updates on the present condition of the roads and what vehicles can effectively and safely travel. The scenarios also provide heat maps that can indicate the hazardous roads and the scale intensity for the awareness of

drivers that may come in contact on the road. The framework is implemented to the development of the application system for mobile.

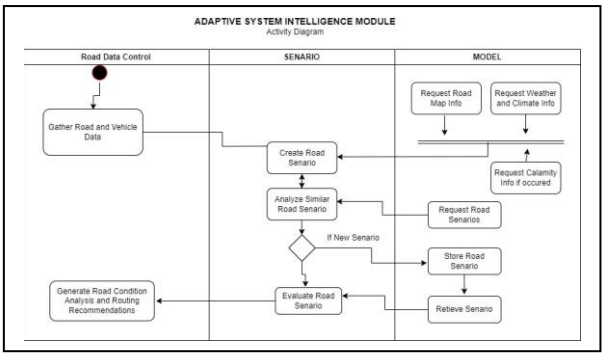

Fig 6. Adaptive System Intelligence Module Diagram

4. Application Development

The development of the application used the gathered road map, hazard map, weather, calamities of the province and the adaptive system framework as the key structure of the intelligence to create the features of the system. Real time mapping and weather gathering API are also used to provide data for inputs. The made use of the integration of Google Map API to the system application to provide the real time mapping, GPS tracking and navigation with routing provided to the drivers. According to the study of Derrow-Pinion et al, google maps can be used to apply algorithms for artificial intelligence of systems to perform better effectiveness for mapping and routing [16]. The API integration can be applied to provide the required mapping and routing information with the adaptiveness as the intelligence of the system. As for the real-time weather data gathering weather Ambee API is integrated. Ambee API is an effective tool in providing weather forecasts on real time climate and weather condition as well as calamities that can occur. The study of Abo-Zahhad made use of the weather Ambee API to be used in an IOT device for irrigation system where in it proved to be an effective API for integration to systems. Integration of the Ambee API to the development of the research provided the weather and climate data required for the adaptive framework intelligence to create scenario-based map data for the features used for the drivers of the province of Albay. Features of the system provides the needs of the drivers for road awareness and the adaptability for travelling on safer routes in climate changes and occurrences of calamities.

The main features developed were as follows:

Hazard Heat Map

The hazard heat maps provide the capability for the drivers to add data encountered hazard on the roads and passages and can also display the recent dangerous or hazardous areas to be encountered. On fig 7, the application provides a map indicating the hazards by green colored markings and tags. The scale of the hazard area is displayed by how big the green marking is placed. These markings are the identified hazards that may consist of damaged roads, debris,

blockages and floods that can provide risks of safety traveling through it. Added feature of the system is shown on fig 8 that display the information for weather conditions, intensity and terrain details of the area combined with the intensity heat map. This feature displays the hazards as road scenario information that provides the drivers the current condition on that green marked area and what vehicles can safely pass through. It also marks a hazard scenario if the current driver has safely pass though and provides information on the capability of the vehicle to be analyzed and display awareness to upcoming drivers.

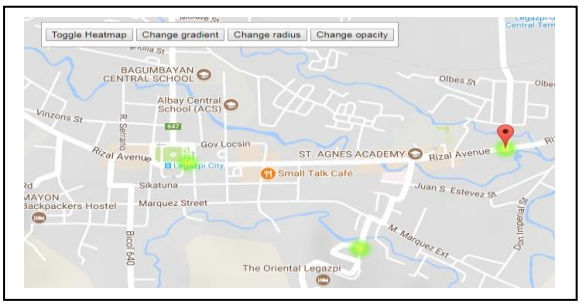

Fig 7. Hazard Heat Map of Areas

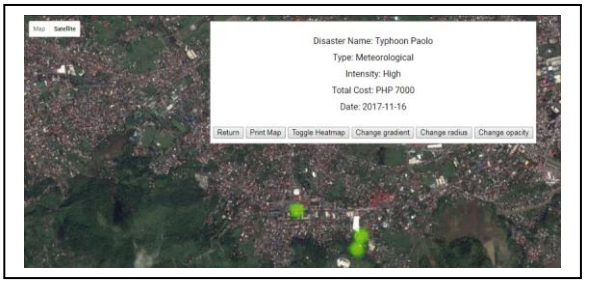

Fig 8. Terrain View and Climate Data with Heat Map

Road Alternatives and Rerouting

The application developed the feature in determining the hazardous areas by identifying them as road scenario displayed in the mapping feature using the integration of Google mapping API to provide alternative routes avoiding and reducing the risks of the drivers in encountering dangers in the roads in certain events such as calamities or unusual weather conditions. The intelligence of adaptive system allows the adaptability to provide the drivers the awareness of incoming road conditions indicated as road scenarios or heat maps on upcoming weather changes or upcoming calamities. The feature then provides alternative routes to avoid hazards and as much as possible reduce the risks in encountering the scale of the hazard. As seen of Fig 9, an example provided by the system creates a road map with an alternative diverting road to avoid the marked red circle indicating the scale and intensity of the hazards that is encountered. Point A represents the current location of the driver going to the indicated point B as the destination. The marked red circle indicates the road scenario consisting the current hazard and the scale of intensity. The red line is the red line that indicates the road that will pass through or encounter the hazard area. The system generates an alternative route as the blue line that can safely traveling while as much as possible avoiding the hazard area of the

map. Another example of the presented by figure 10, demonstrates the waypoints of multiple road alternatives for the divers to take in certain weather conditions. The adaptability of the system generates routing recommendations to drivers that helps them identify roads and routes with the concerned of the capabilities of their vehicles. This allows them to identify which roads to take effectively for their vehicle's capabilities and category on certain terrains in the province of Albay.

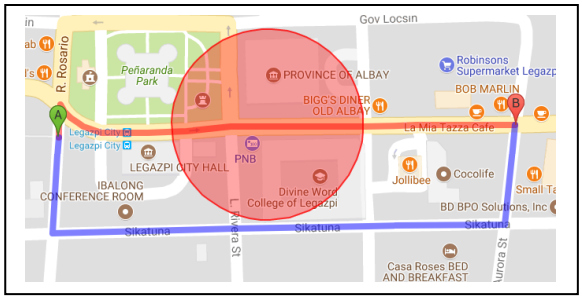

Fig 9. Hazard Intensity Scale on a Recommended Road Route

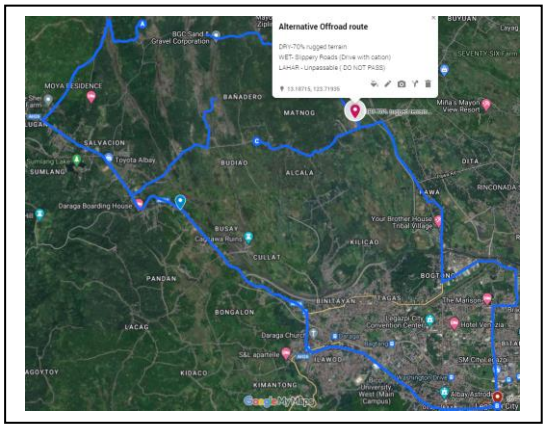

Fig 10. Alternative Routes on Road Mapping

Web Mobile Platform

The system development is implemented on web mobile platform in which the system has the capability to be used to mobile cell phone devices for the portability of the use to the drivers. The mobile platform presents the system in an application web format for the features to be implemented onto multiple mobile devices. With the compatibility of the mapping and weather API the system can run on web integrated browser application provided on mobile devices.

5. Conclusion

The research identified these factors namely the common climate, calamities, danger zones maps and terrain, and the affected municipal roads of the province of Albay that contributed data to the development of the mobile application system. The mobile application for road condition awareness and routing during calamities facilitated awareness and helped identify

safe travel routes between municipalities in Albay province. With the integration of adaptive systems concept, the application provides the necessary information of road mapping and routing availability in different climate status and calamity scenarios that presented in the area. With the use of the google maps API and weather Ambee API, recent map data and climate data are gathered accurately and helped in assessing input data for the application to produce analyzed road condition details, climate and calamity awareness and routing recommendations for travel safety in the region.

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