2016 年度

修士論文

Questionnaire survey and GIS analysis of footpaths studies in Ishikari Subprefecture, Hokkaido

北海道の石狩振興局におけるフットパスのアンケート調査と GIS 解析

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ABSTRACT

Questionnaire survey and GIS analysis of footpaths studies in Ishikari Subprefecture, Hokkaido

Wong Sing Ping (Environmental GIS)

【Background and objectives】

Footpath is a walking path originated from England since the 19th century and it allows people to walk and enjoy the beautiful scenery in the forest, countryside, old streets and visit scattered sightseeing places in urban and rural areas. The purposes of footpaths establishment in Japan not only for recreational but also for regional revitalization and development. The population of footpath users in Hokkaido is getting older and Ogawa Iwao hopes incorporation of more young people in footpath activities. This study was conducted to identify the preferable characteristics of footpaths and footpath maps by the different age groups, to evaluate the characteristics of footpaths and footpath maps in Ishikari Subprefecture and to plan a new footpath route around Oasa Station, Ebetsu which can attract more young adults.

【Methodology】

First, preferable characteristics of footpaths and footpath maps by the different age groups were identified using questionnaire survey. Chi Square Test was used to test statistically significant difference between the age groups for each statement in the questionnaire survey. Next, the map of the study area, Ishikari Subprefecture, Hokkaido with the 24 footpaths was created (Figure 1). The footpaths data were collected by digitizing from the available footpath maps and GPS device and stored in an ArcGIS shapefile. The characteristics of the footpaths were evaluated by analyzing the footpaths data overlay with the DEM (Digital Elevation Models) and land use data using GIS. Whereas, the characteristics of footpath maps were evaluated based on whether regional resources and facilities (public transportation, sightseeing places, toilets and rest places) are mapped on existing footpath maps. Lastly, ArcGIS Network Analyst was used to plan and propose a new footpath route near Oasa Station, Ebetsu that preferred by young adults, according to the result of preferable characteristics of footpaths obtained from questionnaire survey.

【Results】

The rate of response in this questionnaire survey was 31.33%. Different age groups have the different perspectives to the "preferable length of footpath" because statistically significant difference (p value = 0.001) was found. Young adults preferred "3-5 km", middle-aged preferred "5-7 km" and older adults preferred "7-10 km" of footpaths respectively. Whereas, different age groups have the same perspectives on the preferable "theme", "type of footpath", "place to start and finish points" and "type of the footpath surface" as well as " preferable type of footpath map" and "which geographical information to be important included in the footpath map" (Table 1). Therefore, the 24 footpath data sheets were created after evaluation of the characteristics of footpaths. The 24 footpath data sheets included a footpath slope change map, elevation graph and land use composition pie chart were created after GIS analysis in order to allow footpath users can have a better understanding in the landscape aspect (Figure 2). For evaluation of footpath maps, 16 out of the 24 footpaths have public transportations, sightseeing places, toilets and rest places that are completely mapped in existing footpath maps. Lastly, the shortest footpath route that connected the stops, preferred by the young adults such as sightseeing places, forest areas, toilets and rest places (parks) was planned by ArcGIS Network analysis and a map was created using GIS (Figure 3).

北海道の石狩振興局におけるフットパスのアンケート調査と GIS 解析

Wong Sing Ping（環境 GIS 研究室）

【背景と目的】

フットパスとは、19 世紀のイギリス発祥の森林や田園地帯、古い街並みの美しい景色を楽しみ、都市と農村で観光地をゆっくりと参観することが可能な「歩くことができる小道」のことである。日本におけるフットパスの目的はレクリエーションだけではなく、地域の活性化や発展の目的もある。北海道におけるフットパス使用者の人口は高齢化しているが、フットパスの活動には、多くの若者が必要であり、その期待も大きい。そこで本研究では、異なる年齢層へのアンケート調査とフットパス地図により、フットパスの好ましい特徴を明確にし、石狩振興局のフットパスとフットパス地図の特徴を評価して、より多くの若者を引き付けるための、江別市の大麻駅周辺の新しいフットパスルートをプランニングする。

【方法】

まず、アンケート調査により、フットパスとフットパス地図の好ましい特徴を特定した結果、カイ 2 条検定で、異なる年齢層による統計的な有意差が得られた。次に、石狩振興局に位置する利用可能なフットパス地図（図１）を作成した。その作成について、地図が実在したフットパスについては、紙地図のデジタイジングを行い、それ以外のフットパスについては GPS デバイスを用いてデータの収集を行い、地図を作製した。以上のデータは、ArcGIS により、DEM（標高モデル）や土地利用データと重ね合わせ、全てのデータを解析することによって、フットパスの特徴を評価した。フットパス地図の特徴は、地域資源と施設（公共交通機関、観光地、トイレ、休憩場所）は、既存の地図に掲載されているかどうかによって評価をした。最後に、ArcGIS の Network Analyst を使用して、アンケート調査による若年層のフットパスについて、調査で得られた好ましい特徴に応じて、江別市大麻駅周辺の新しいフットパスルートをプランニング・提案した。

【結果】

上述したアンケート調査の有効回答率は 31.33%であった。アンケート調査における、「望ましいフットパスの長さ」に関する異なる年齢層の回答結果には統計的に有意な差(p 値=0.001)がみられ、若年層は「3-5 km」、中年は「5-7 km」、高齢者は「7-10km」のフットパスをそれぞれが好ましいと評価していた。その一方で、上述の調査における好ましい「テーマ」、「フットパスの種類」、「スタートとゴールの場所」、「フットパスの地面の種類」、「フットパス地図の種類」、「フットパス地図に含まれる重要な情報」については、異なる年齢層が同じ価値観を持っていることが明らかになった(表１)。そのため、本論では、フットパスの特徴を詳細に評価した結果に基づき、利用者向けの全てのフットパスのデータシートを作成した。そのデータシートには、フットパス利用者が景観面でより良い理解を深められるための、フットパスの傾斜変化マップ、標高のグラフ、および土地利用に関する円グラフ図が含まれている（図 2）。全てのフットパスのうち、16 のものは、既存のフットパス地図に公共交通機関、観光地、トイレ、及び休憩場所が完全に地図化されている。最後に、若者が好む観光地、森林地帯、トイレ、及び休憩場所(公園)を結んだ最短のフットパスルートを、GIS Network Analyst によってプランニングし、マップを作成した（図 3）。

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Lord of His guidance and giving me the strength to complete this study within the time given. Firstly, I wish to thank my supervisor, Professor Masami Kaneko for her guidance, advice, comments and valuable suggestions throughout this study. I also would like to thank Dr. Shin'ya Kawamura and PhD student, Kanji Hashimoto who has given me advice and comments that related to the GIS. I also wish to thank Professor Tsuyoshi Yoshida and Professor Buho Hoshino who as examiners for checking my master thesis and given me comments.

A special thanks to my family who has given me their support all the time. I also want to thank to all my friends who gave me suggestions and support during the preparation of this study. Besides that, I also want thank to the Koichiro Ogawa and Yamaguchi Junya who help me in questionnaire survey distribution. Finally, I wish to express my sincere gratitude to all who have helped me a lot in this study.

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CHAPTER 1 INTRODUCTION

1.1 Study Background

In recent years, there are many new walking cultures such as footpath from United Kingdom (UK), long trail from USA, Olle from Korea and etc. was introduced to Japan from overseas. Footpath in Japan considers as a regional tourism resource because it allows people to access and visit scattered interesting tourist spots in urban and rural areas (Izumi & Hirano, 2015). In additional, the purpose of footpaths establishment not only for recreational but it also can help to revitalize the regions by promotion of rural tourism and motivate local residents especially in farmland regions to take part in rural development. Therefore, footpath in Japan is a path or trail that people can walk through the sightseeing places and the environment with a variety of elements such as countryside, forests, grasslands, paddy fields, old towns, residential areas, river, coastline or industrial zone. Therefore, they can enjoy nature, culture, landscapes, history that uniquely at there as well as experience agriculture, fisheries and dairy farm activities when walking along the particular footpath (Ogawa, n.d.).

Walking is one of the popular sport activities among Japanese age 20 and above. According to the research done by the Sasakawa Sports Foundation (SSF), the percentage of Japanese people who walks increased from 11.6% in 2002 to 17.8% in 2010 (Watanabe *et al.*, 2010). Since the number of walkers in Japan is increasing, the number of footpaths in Japan is also increasing every year and becoming more and more popular. For example, the number of people join the Misato Footpath walking event in Japan mainland with footpath walking guide were increased double which is from 761 people in 2013 to 1362 people in 2014. However, the number of people who walked along the footpaths is believed more than the statistics above. This is because some people they walked by themselves without a guide. Many Japanese enjoy footpath walking because they can enjoy the local scenery and old townscapes in suburban and rural area (Takanashi, 2016).

Footpath is quite new in Japan because footpaths are starting build in the late 1990s to 2000s if comparing with England, UK. In Japan, there are around 70 footpaths with 261 numbers of footpath courses at the end of March

2013. The total length of footpath courses distributed in whole Japan is around 2,961 km. Hokkaido has the highest number of footpath (47 footpaths, 135 courses with a total length of 1,681 km) if compare with other region in Japan (Izumi & Hirano, 2015). However, the total length of footpaths in Japan still considered shorter than England because the total length of footpaths in England is around 188,700 km. In Japan, all roads are considered public and there are no Rights of way law. However, there is a Right of way Law and people need to follow the legal infrastructures when they want to start to build a new footpath route in England. The footpaths in Hokkaido are easy to build and usually maintain by the local residents and land owners themselves without government because it don't require large scale of public works (Hirano & Izumi, 2012).

This footpath walking activity started in Hokkaido since 20 years ago and both the local community and NGO have designed many new footpath routes according to their knowledge and familiarity with the particular areas. For example, Teine and Hoshioki footpaths were designed and planned by the university students in Teine region, Sapporo in order to promote more young people using the footpaths and exploring more attractive places. Availability of the footpath map can let more people know the location of footpath routes and sightseeing places that people can walk and visit. Therefore, the main purpose of footpath establishment in Hokkaido which is regional revitalization can be achieved soon when people start using those footpaths (Sapporo Teine City Office, 2016). Besides, the communication between outsiders and local people along the footpaths also can be promoted (Matsuda *et al.,* 2009).

Designing footpath routes with their preferable characteristics and fulfil their demands are the most important factors in the footpath projects. Questionnaire survey is the faster and cost saving method in order to know the preferable characteristics of footpaths and footpath maps by different age groups. Besides, the process of footpath routes planning projects usually time consuming and need a lot of human resources in the actual place surveys. For example, they need to look for and confirm the availability of facilities such as toilets and resting places along the footpath routes during the footpath planning process. Therefore, Geographic Information System (GIS) can improve the effectiveness and efficiency in the footpath routes planning projects.

GIS can be a useful tool in footpath studies because different spatial data layers are allow to visualize and combine in GIS (Kokkinidis *et al.*, 2013). For example, the location of regional resources such as toilets along the footpath can be visualized easily using aerial photography. Then, geospatial analyses such as a network analyst in ArcGIS also can be quickly conducted to create the optimal new footpath routes. Besides, GIS can be an effective tool to study the relationships between footpaths and topography, land use and geology for footpath evaluating, planning, managing and mapping. For example, aerial photography, digital elevation model (DEM) and land use data can be a good source of data for the footpaths studies using GIS.

1.2 Justification and purpose of the study

According to Iwao Ogawa, there is an issue about the population of footpath users is getting older in Hokkaido. Therefore, there is a need to incorporate more young people in footpath walking activity (Japan Footpath Organization, 2012). This study was conducted by using a questionnaire survey to identify the preferable characteristics of footpaths by different age groups people. Those footpaths that designed according to their preferable characteristics can attract more people from different age groups to use it in a short time. The location of footpaths distributed in Ishikari Subprefecture involved different kinds of land use or landscape. DEM data, land use data and existing footpath maps can be used to evaluate the characteristics of footpaths and to know whether it is fulfilled with the preferable characteristics of footpaths and footpath maps by the different age groups.

Besides, interesting footpath courses that preferred by the young adults group can be planned using GIS after questionnaires survey. GIS also can be a good tool to build footpath datasets, create a wide range of planning, perform spatial analysis and display footpaths in the maps in this footpaths study. Planning new interesting footpaths in Ebetsu, Hokkaido also able to encourage more young people using footpaths around them because footpaths can encourage healthy lifestyles, boost the local economy and create awareness of the importance of nature. Besides, developing footpath also is a very effective method of protecting the natural environment.

According to the Bureau of Tourism (2014), the main purpose of tourists visit Hokkaido from 2002 to 2011 is looking around nature and scenic spots in Hokkaido (categories of nature appreciation). Therefore, footpaths also can become a new tourist hotspot in just a short period of time if there are good maps for the particular footpath (Kotaka, 2009). At the same time, available of footpath map can let more people know and enjoy walking along the footpaths in Hokkaido with the abundance of beautiful scenery and visiting sightseeing places. Besides, the ways to distribute the footpath maps also important because it can let more people to know and use it.

1.3 Objectives of the study

The purposes of this study showed as below:

1. To identify the preferable characteristics of footpaths and footpath maps by the different age groups using questionnaire survey.

2. To evaluate the characteristics of footpaths and footpath maps in Ishikari Subprefecture according to the DEM, land use data and existing footpath maps.

3. To plan new footpath route around Oasa Station, Ebetsu which can attract more young adults using ArcGIS Network Analyst.

CHAPTER 2 LITERATURE REVIEW

2.1 Footpaths

Footpath is a term that is used in Japan to describe a path and it is the term originated from England since the 19th century. In the olden times of England, footpaths are a path that connected people to their nearby village and church. Nowadays, footpaths in England are used for health walks. In the rural regions of Japan, footpaths are also getting more popular because it can promote rural tourism and encourage older people to stay fit (Nomura, *et al.*, n.d.). Footpaths link human to the natural environments, countryside or urban areas in the easy way.

Overall, footpath can be paved and unpaved in different area. Paved footpaths usually found in urban area such as garden, public spaces, urban parks and it is called as lanes or alley. Unpaved footpaths usually found in national parks, farmland, conservation area and other natural areas and it is called as trail or long distance trail. Nowadays, most of the footpaths are built and allow people can access to non-roaded areas safely. Footpaths are usually used by people for recreation activities such as running, wildlife observation and etc. (Marion & Leung, 2001).

2.1.1 Terminology of footpaths

Different countries have different definition on footpaths. In Japan, Japan Footpath Organization (2015) stated footpath is "*a path that allow people to walk and enjoy the beautiful scenery in the forest, countryside, old streets and so on.*" In England, GOV.UK (2016) stated footpath is "a path that public going on foots only for walking, running or other recreational purpose as well as wheelchair users and they are protected by the Right of Way." England footpath usually lets public walking randomly in rural areas with beautiful natural scenery and old townscapes (Izumi & Hirano, 2015). In New Zealand, New Zealand Transport Agency (2009) stated footpath is "the part of road or other public place built and laid out for pedestrian use. Footpaths can also run through the parks, roadside and other open spaces.

2.1.2 Other terms that similar to footpaths

a. Nature trail

Nature trail is also known as educational trail and it is a path that design through a forest to provide people opportunities to observe and learn about the flora and fauna. The nature trails can be found in a national park, forest, urban greenbelts, suburban estates and other conservation area. The nature trails also called as educational trails because some nature trails are designed with some interesting environmental information. Therefore, while visitors enjoy in walking, they also can know the important role of nature trail in protecting the natural environment and the value to protect the environment (Timothy & Stephen, 2014).

The national nature trail is a long distance route that built in the countryside of England and Wale for walking, cycling and horse riding. These natural trails are established to protect the natural areas from post-war development. The total distance of this nature trail more than 4000 km routes and there are consisting of 15 trails. People can easily reach all of the national nature trails because buses and train services to the nearby villages or towns are provided (Natural England, 2013).

b. Olle trail

The origin of Olle trail is from Jeju Island, South Korea. The meaning of 'Olle' in the Jeju native dialect of Jeju Island is a narrow path that links people to a village. Olle trails are footpaths that surround the whole Jeju Island and it is ranging from 5 km to 22.9 km. The Olle trails are divided into 26 courses with total 410 km and it is only can access by walking and not by cars (Ogasawara & Nakajima, 2015). These paths can bring visitors enjoy different sceneries such as villages, beaches, mountain, and forests in Jeju island with minimal environmental impact. The Jeju Olle Foundation is trying to use natural materials to build the trail routes. This is to help maintain the natural landscape of the Jeju Island (Taylor, 2011). This Jeju Olle trail success attracting more than one million visitors since 2011 and it promotes the local ecotourism business (Ogasawara & Nakajima, 2015).

Besides, there are also present of Kyushu Olle in the 7 prefectures of Kyushu, Japan. The Kyushu Olle trails are opened in February 2013 with four Olle courses only but in December 2014, the Kyushu Olle is divided into 15 courses with totaling 177.4 km. These paths can bring visitors enjoy in the local history, culture, hotspring and the beauty of nature. The Kyushu Olle is developed with the cooperation with the Jeju Olle Organization (Welcome to Kyushu, 2015).

c. Dule

The meaning of "Dule" is the trail or line that bounds a circle and it is connected to the edges of areas. This Dule trail consists of 22 courses that run along the boundary of Jirisan Mountain, Korea with total length 274 km. This trail encourages visitors close to the local people and promote nature-friendly tourism (Im, Yoon & Lee, 2013).

2.2 England footpath

In England, People have the "Rights of way" to walk through some land or open access land with the purpose of national recreation or others. For private land, people still can able to access when the landowner open their lands and allow people access through their land. But before that in the 18th century, people are not allowed to walk randomly in the countryside. This is because many landowners in England closing their roads of their lands when the countryside rambling (national recreation) become popular (Izumi & Hirano, 2015).

This movement causes people start to protesting for their walking right. At the same time, these protest have forced the birth of English Footpaths. Therefore, people are allowed to walk freely on the paths that designated as public, regardless it is owned by private or public when the Right of Way Law was enacted in 1932. The England footpath is managed by government or local authorities (Izumi & Hirano, 2015).

According to the Public Rights of Way Law, motorized vehicles cannot use footpath because it is a path for people to walk on foot only. Footpaths can be used by normal people for walking and running. Footpaths also can be used by disabled people with wheelchairs. Some council in England also provides

health walk activity for local people. There are also have some people using footpaths as rehabilitation purpose (Nomura, *et al.*, n.d.). In addition, footpaths in England are usually marked with sign or arrows in order to prevent footpath user loss their way. Apart from that, walking footpath in the rural areas in England also can help to protect the natural environment there by following the Countryside Code which is Respect other people, Protect the natural environment and Enjoy the outdoors. (GOV. UK, 2016)

2.3 Japanese footpaths

In the last 20 years, Japanese footpaths have been rapidly developed in whole Japan. Although most of the popular footpaths that usually have a length which less than 10 km. For example, Misato footpaths in Mainland Japan have 15 courses and the footpath courses, distance range from four to eight kilometres which took around two to three hours to complete walking in each footpath course. In addition, Japanese footpaths usually use path and roadsides that can be used by pedestrian and bicycle users in footpath courses planning. Apart from that, there are also present of long-distance footpaths (long trails) with each course more than 30 km. People who use the long-distance footpaths usually need an overnight stay (Izumi & Hirano, 2015).

There is no Right of Way Law applied in Japanese footpaths and it is emerging because the walking population is increasing and the interest of the public in the natural environment and health are rising since the late 1990s (Izumi & Hirano, 2015). Besides, the problem of overpopulation in urban areas and depopulation in rural areas since the 1960s also cause them eager to establish the footpaths in the rural areas in Japan (Imai, n.d.).

Whereas, the main force drive to the establishment of the footpath project in Hokkaido is the forum held by the Hokkaido Shimbun Press in Sapporo in 2002. In this forum, they mentioned footpaths in Hokkaido established based on the recreational opportunities and the demands of urban residents and visitors from other places to revitalize the regional area. Footpath projects are supported by more than 300 people who attended the forum showing that they need footpath in Hokkaido (Izumi & Hirano, 2015). Healthy green tourism in the rural areas also can be promoted through footpath walking activities (Nomura *et al.*, n.d.).

However, there is present of problem during footpath routes planning in Japan which is having of the problem of land ownership. Mostly private lands in Japan are not allowed outside people walk through their lands (Matsuda, *et al.,* 2009). Although it is rare occurring in Hokkaido, but there is still have some open space areas or lands in Hokkaido didn't allow people trespassing it. Difference between England and Japanese footpaths are shown in Table 2.1.

Table 2.1 Difference between England and Japanese footpaths (Izumi & Hirano, 2015)

	England Footpaths	**Japanese Footpath**
Right of way Law	Yes	No
Paths	Using path freely that designed for walk with foot only	Using path and roadsides that can be use by pedestrian and bicycle users
Reason of emerged	Agreement between landownership and enjoyment of public recreation	Rising of interesting of public in the environment and health
Purpose of establishment	National Recreation	Regional revitalization

2.3.1 Purposes and functions of footpaths in Japan

"Regional Revitalization" is the common purpose of establishing footpath projects in Mainland Japan and Hokkaido. In Mainland Japan, government redevelop *rido* in regional footpath development to reactivate local communities (Izumi & Hirano, 2015). The *rido* in Honshu and Kyushu are created for local people to access, transport as well as the place for people daily communication during the beginning of the Meiji period (1868-1912). The *rido* is a non-designated road, strip roads, small paths or recreational trails. There is no road law apply and municipal government nowadays usually use those paths to build footpaths. The function of the *rido* lost gradually because the number of car increase and community deterioration (urbanization). Due to the comprehensive law on decentralization in 2000, the *rido* were ceded to municipal government and become their administrative assets for development. Then, municipal government combines former rido into footpaths projects in Honshu and Kyushu (Izumi & Hirano, 2015).

Footpath projects in Japan can revitalize regional because according to the Irish Sports Council (2012), they found that trail users have the direct economic expenditure on items while walking such as foods, drinks, and equipment. Therefore, the local economy can be boosted and regional revitalization can achieve in a short time. Besides, a study done by Christie and Mattews (2003) also shows that footpath walking activities have a socioeconomic impact to the suburbans or rural economy. It is not only generating income but also provide full-time equivalent jobs for the local people.

Another purpose of establishing footpath projects in Mainland Japan and Hokkaido are they want to promote rural tourism by share their lifestyle and attractive areas with the visitors (Hirano & Izumi, 2012). For example, Yasumichi Ito and his colleagues who work together to build a footpath in Nemuro, Hokkaido said they are very willing to let visitors come and visit the footpaths in some region of their ranches. Visitors can enjoy walking and see dairy cow grazing activity along the Nemuro footpaths. Footpath walkers also can experience milking and farming activities on farms there.

Footpaths can serve as resources for conducting environmental education. Public using those paths because they want to learn more about nature such as plants, animals, geology and threats that can destroy the nature (Bogdanowicz *et al.*, 2014). Footpaths with an environmental education element can promote awareness of public about their surrounding nature environment. Besides, the footpaths in Nemuro also include some historical place such as old Japanese National Railways which can let walkers a feel for the history of development in Hokkaido (Kotaka, 2009). Footpaths with the combination of the natural and historical characteristics as well as the dairy farms around have let the number of visitors visit to Nemuro increased eightfold within 10 years (Kotaka, 2009).

Footpaths can serve as walking facilities for public to exercise, interact and communicate. According to Hirano & Izumi (2012), footpath can let people enjoy the beautiful landscapes, experience the life of local people through communication when they walking through footpaths. For example, some non-profit organization in Mainland Japan such as NPO Midorinoyubi Footpath built the footpath in order to promote interaction between new and old residents as well as to let people enjoy the mountain scenes (Kotaka, 2009).

Healthier lifestyle can be promoted with the availability of footpaths around them. Footpaths also can conserve the nature and unique landscape. For example, footpath was planned in Tama Hills, Kanagawa Prefecture to conserve the landscape of satoyama. Besides, the local NPO also tries to increase the awareness of local people on landscape conservation through footpath activities (Miyazaki & Aso, 2004).

2.3.2 Difference between footpaths in Mainland Japan and Hokkaido

There is also some difference between the footpath projects in Mainland Japan and Hokkaido which is footpaths in Mainland Japan usually designed inside the communities with many local people staying around. This is because footpaths in Mainland Japan developed by the using *rido*. Then, visitors can directly experience a regional lifestyle when walk through the footpaths. Whereas, footpaths in Hokkaido usually set through the existing roads, public and private lands. This also means that the number of residents and landowners are relatively low along the footpaths if compare with the Mainland Japan (Izumi & Hirano, 2015). There are no footpaths in Hokkaido use reactivating *rido* functions as in Mainland Japan.

The footpath planning and managing system in Mainland Japan differ from Hokkaido footpaths because footpaths in Mainland Japan usually planned and formed by local governments by asking participation of community action groups (The Japan Footpath Association) or local residents (Hirano & Izumi, 2012). Whereas, footpath projects in Hokkaido usually don't involving municipal government and it is usually planned, designed and promoted by local communities, local people and NGO (Takanashi, 2016). For example, the footpath promoting activities has been led by the Eco Network, a citizen's ecological group which based in Sapporo City (Izumi & Hirano, 2015). In addition, footpath course in Tobetsu, Hokkaido was planned by the high school students and local people.

Overall, footpath projects are relatively easy established and planned in Hokkaido compare to Mainland Japan. However, sometime they still confronted problems in negotiation with the land owners and other residents around the footpath courses in the process of footpath development in Mainland Japan and Hokkaido. This is because the land owners and residents around footpaths

concerns over their privacy and security (Hirano & Izumi, 2012).

2.4 GIS analysis in previous footpath studies

Geographic Information System (GIS) is a computerised system that usually used for spatial (geographical) and non-spatial data capturing, storing, managing, analysing and visualizing. People can easily see and figure out the patterns of different types of data that related to position on surface of earth on one map through GIS. This is because GIS allows different types of data overlay on each other on a single map to perform analysis and those data can be handled in raster and vector form as well as tabular format. GIS allowed people to upload and store the data in table form. There are many different types of data about people, land and location of different objects can be compared and displayed using GIS. Besides, GIS allows people easily doing the maps updating because it is only need to add the updated data to the GIS (Rutledge *et al.,* 2011).

In addition, obtain the visual as well as inquiry information about geographical data can be carried out using GIS. For example, GIS using spatial data to investigate some questions related to the tourism development such as location, routing to and through the site, resource use and condition of the area (as cited in Dye & Shaw, 2007). Overall, GIS is a useful and efficient tool that can help people to save time and costs to make decisions as well as improve their services.

GIS also can be the effective tool in different type of footpath studies. For example, creation of footpath inventories by using GPS can let people map footpath position accurately and able display and analysis in GIS (as cited in Marion & Leung, 2001), footpath hazards digitization and visualization to display the hazards at each location (Tullis, 2007), footpath map creation, footpath accessibility by spatial and network analysis (Reneland, 2003), highway route evaluation and designation by least-cost path analysis (Effat, 2013), recreational trails with lowest possible impact planning in protected areas by least-cost path algorithm within a GIS framework (Tomczyk & Ewertowski, 2013a), surface changes of the trail assessment by digital elevation models (DEMs) of difference (Tomczyk & Ewertowski, 2013b) and finding the most efficient route and directions by Network Analysis (Kumar &

Kumar, 2016).

2.4.1 ArcGIS Network Analyst

ArcGIS Network Analyst is a network-based spatial analysis tools that allow users to solving the problems of routing. For example, find the optimal travel routes, find the closest facilities, find a service area, solve multi-vehicle routing problems and find travel directions (Kumar & Kumar, 2016). In this study, ArcGIS Network Analyst was used to find the optimal footpath walking routes for footpath users. This Network Analysis allows the shortest, quickest and the most scenic footpath routes can be planned on the road network from one stop to another one or more stops depending on the criteria such as distance and time.

Network Analyst in GIS was used in the study of Turk & Gumusay, (2004) to determine the shortest distance between the selected sightseeing places. GIS is a tool that can apply in tourism because it can be to use to determine the shortest routes that link between the sightseeing places such as historical and beautiful natural places. By using GIS with available high resolution data and specific criteria that will consider in footpath planning such as scenic views, construction cost, environmental sensitivity and others, it can used to display and identify the optimal footpath routes.

2.5 Questionnaire survey

Questionnaire survey is a quantitative research and an effective tool that can generate quantitative (numeric) data by collecting information (attitudes and behaviors) from a selected target group of people (Taylor-Powell & Steel, 1996). Questionnaire survey is the most common technique that used by researchers to gather information from respondents in order to know their attitudes or behaviors. The data collected from questionnaire survey can be used to do evaluation and statistical analysis.

There are different types of questions can be design in the questionnaire survey such as open, closed-ended questions; multiple, single responses; ranking and rating. The benefit of using questionnaires is able to

collect data about behaviors, attitudes and knowledge from different people when the resources are limited. The questionnaires also cost and time save as well as can collect large response in short time. In the previous footpath study that conducted by Izumi (2015), a questionnaire survey was done to study the preferable characteristics of footpaths by the footpath users.

The data analysis of quantitative data such as closed-ended question is relatively easy because it can completed by using descriptive and inferential statistics. However, data analysis for qualitative data such as open-ended question is difficult to analyze because it is hard to code and categorize it (Akbayrak, 2000). This is because open-ended questions allow respondent to answer their own opinion or answer freely without limited by the fixed answers. Both types of questions have their advantages and disadvantages.

2.6 Chi square test

The Chi-square (χ^2) test of independence also known as the Person Chi-square test and it is a non-parametric tool that usually used to test whether there is statistically significant difference of two categorical variables (McHugh, 2013). The Chi-square statistic was developed by Karl Pearson in 1900 (Wuensch, 2011). The observed and expected values are needed to calculate the chi-square test statistic. Chi square test also can be performed in Excel by using an Excel CHITEST function to calculate the p value. The p value is shown in probability for the chi-square statistic and the significance level usually set at 95% ($p = 0.05$). If the p value is less than or equal 0.05 mean it is statistically significant and p value more than 0.05 mean it is not statistically significant.

2.7 Jaccard Similarity

Jaccard similarity also known as the Jaccard Index and it is a statistic that used to measure the similarity between samples set. Jaccard index is usually used for species association analyses and the index ranged from 0 to 1, 0 mean the samples are not similar and 1 mean closely related to each other and all species present in both samples (similar). Jaccard similarity usually used in ecological studies such as identification on the presence or absence of species between several studies sites (Real, 1999).

2.8 Simpson's and Shannon-Wiener diversity Index

Simpson's and Shannon-Wiener diversity Index both are the common indices to measure the diversity in ecology. It is not only used to calculate diversity of particular species but also landscapes. For example, it is also applied in urban studies such as measuring the diversity of landscape (Kajtazi, 2007). The importance of Simpson's index on the richness is higher than evenness. However, Shannon-Wiener Index of Diversity is heavily dependent on richness and evenness. Nagendra (2002) also stated that the Shannon-Wiener index is better than Simpson's index in quantifying the landscape diversity

Simpson's Diversity Index is a common diversity measurement to measure of species diversity developed by E. H. Simpson in 1949 (Allaby, 2010). The value of Simpson's Diversity Index ranges from 0 to 1. The value of '0' mean no diversity and value of '1' mean infinite diversity or high variety of land uses. The larger value of Simpson's index means more diverse (Barcelona Field Studies Centre, 2016).

Shannon-Wiener diversity Index is another common diversity measurement that developed by Claude E. Shannon and Norbert Wiener in 1949 (Spellerberg & Fedor, 2003). The two main factors, richness and evenness are usually taken into account when measuring diversity of the particular subjects or categories. For example, when the richness and evenness of the land use categories are increasing, the Shannon-Wiener index also increases. It is also means that the landscape diversity increasing. Generally, the values of Shannon index range between 1.5 and 3.5 and it is rarely greater than 4 (Magurran, 2004).

CHAPTER 3 METHODOLOGY

3.1 Study areas

3.1.1 Ishikari Subprefecture, Hokkaido

Ishikari Subprefecture is a subprefecture located in the western part of the Hokkaido. Hokkaido is an island located in the northern part of Japan and it is the largest prefecture in Japan. Hokkaido also is a region rich in natural features and there is nature-based tourism or ecotourism is promoted. Ishikari Subprefecture covers 3,539.86 square kilometers with a population of 2,363,381 (Ishikari Subprefectural Bureau, 2015). The elevation of Ishikari Subprefecture was ranging from 0 to 1487.21 m. The study area, Ishikari Subprefecture included Sapporo, Ishikari, Ebetsu, Eniwa, Kitahiroshima, Chitose city, Tobetsu Town and Shinshinotsu village. Sapporo is both of the capital of Hokkaido and Ishikari Subprefecture and Sapporo consists of fifth largest population in Japan. There are total 24 footpaths located in this study area (Figure 3.1).

3.1.2 Ebetsu, Hokkaido

The study area of new footpath planning using ArcGIS Network Analysis in this study is Ebetsu, Hokkaido. Ebetsu is located in Ishikari Subprefecture and the distance of Ebetsu to Sapporo is approximately 17 km only. The total area of Ebetsu is around 187.38km^2 and the population recorded in year 2015 is 120,677 people with population density 644 / km^2 (Ishikari Subprefectural Bureau, 2015). In the history of Ebetsu, the ceramic (red brick) industry played an important role. Nowadays, there is many public and private buildings still remain this characteristic of building in Ebetsu. Moreover, there are only four brick historical factories remained in Ebetsu (NPO Yakimono 21, n.d.). All of this historical brick building has become a landmark in Ebetsu. In Ebetsu, there are also consist a lot of interesting places that people can visit such as Nopporo Prefectural natural park, ceramic art centre, historical museum, shrine, farms, and others. It is a good place to do footpaths planning in order can let more people to discover, explore and learn the history and natural in Ebetsu.

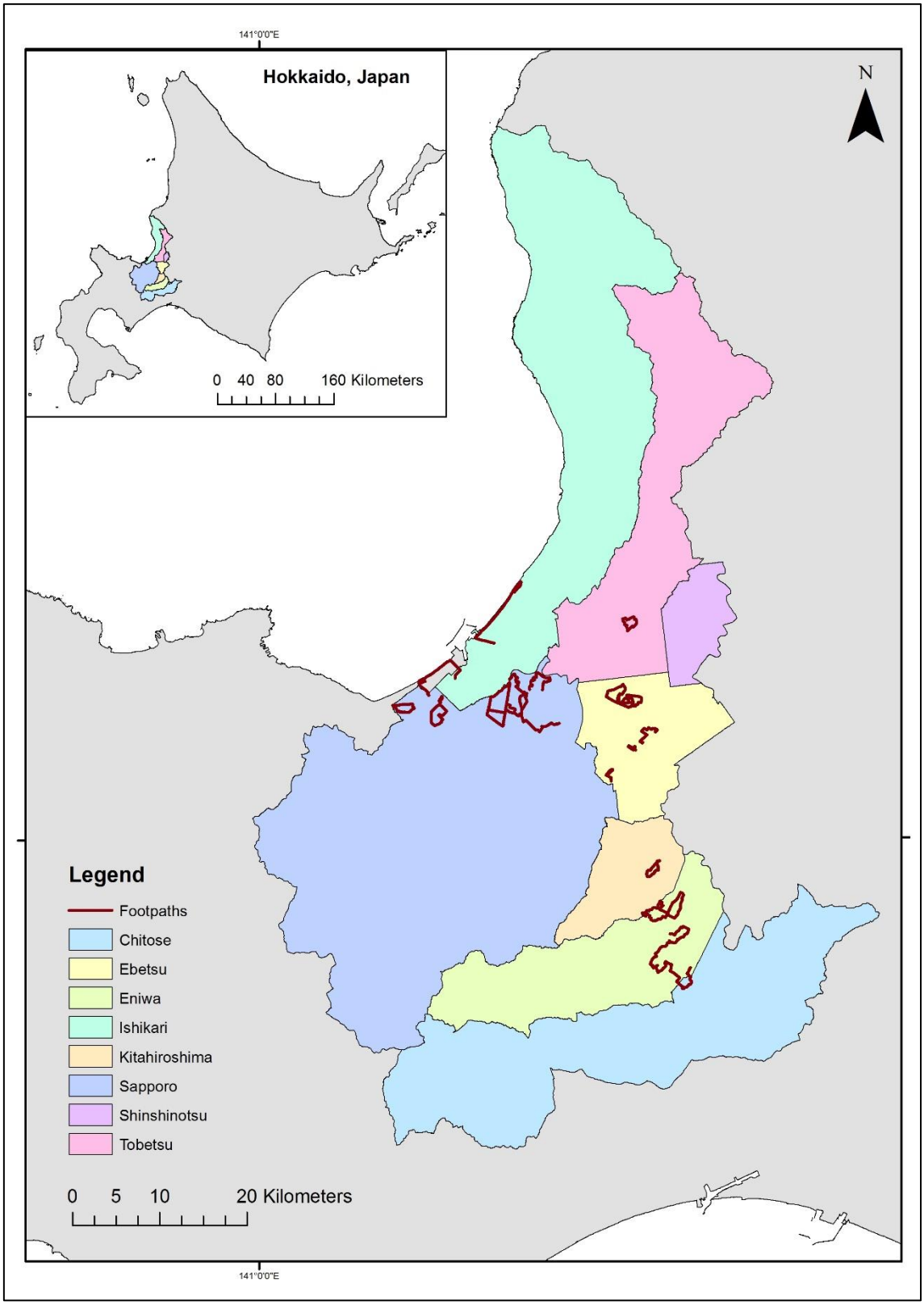


Figure 3.1 Map of the study area, Ishikari Subprefecture, Hokkaido with the 24 footpaths

3.2 Software used

The software listed below was used in this study:
a) ArcGIS was used to display, processing, analyzing the spatial data layers
b) Microsoft word was used in presenting this study
c) Microsoft Excel was used in data analysis and bar graph creating

3.3 Preferable characteristics of footpaths and footpath maps by the different age groups using questionnaire survey

A survey research method which is questionnaire was applied in this study. The questionnaire survey that conducted in this study was the quantitative research method. The data that collected from the questionnaire survey can be counted or expressed numerically and performed the statistical analysis.

3.3.1 Questionnaire design

In this study, a total of 19 questions (closed-ended questions) and one open ended question was designed and the preferable characteristics of footpaths and footpath maps by the different age groups were identified. A short and brief introduction and objectives were described to let respondents to understand the purpose of this study.

The questionnaire survey was divided into three sections. First section in this questionnaire survey included six questions that inquired about respondents' background. Second section included five questions that inquired the preferable characteristics. Third section included three questions that inquired the preferable characteristics Fourth section included five questions that inquired the level agreement about the footpaths and footpath map. Fifth section included the one question that inquired the opinion and suggestion about footpaths.

3.3.2 Questionnaire distribution and collection

The questionnaire survey was conducted in the 21 August 2016, Footpath walking event that held in Teine Area of Sapporo City. A questionnaire survey was distributed at this event because there are many footpath users who not

only come from Hokkaido but also Japan Mainland (Kyushu). Besides, there are also many universities and high school students participated in this event.

3.3.3 Methods of data analysis

Before data analysis, each questionnaire was coded in order to facilitate analysis. The respondents in this questionnaire survey were divided into three age groups which is young adults (15-39 years old), middle-aged (40-59 years old) and older adults (above 60 years old).

For single response questions, descriptive statistics which are a calculation of frequencies and percentages by the different age groups on each statement were performed for data analysis. The Chi-square test was used to test whether there is statistically significant difference among the age groups in each of the statements. The p value of the Chi-square test was calculated by using the Excel CHITEST function. If the p value less than 0.05, mean statistically significant difference between the age groups. If there is not statistically significant difference, there is the same perspective for the preferable characteristics of the footpaths and footpath maps by the different age groups.

i) Chi-square Test statistic (McHugh, 2013)

$$X^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

χ^2 represent the cell Chi-square value
O represent observed value
E represent expected value

ii) Chi-Square expected value

$$E = \frac{MR \, x \, MC}{n}$$

E represent the value of cell expected
M_R represent the row marginal for that cell
M_C represent the column marginal for that cell
n represent the total sample size

For multiple response questions, descriptive statistics which are a calculation of frequencies and percentages by the different age groups on each statement were performed for data analysis. Besides, the Jaccard similarity index was used to compare the similarity of two variable groups. The Jaccard similarity index ranged between 0 and 1 and it is calculated using Excel. The higher on the Jaccard similarity index of the pair of variables mean they are closely related. The similarity value of every pair of variables was calculated and presented in Similarity Matrix table.

i) Jaccard similarity index (Real, 1999)

$J = C / A + B - C$

J represent Jaccard similarity index
C represent the number of shared variables
A represent the total number of variable a
B represent the total number of variable b

For the Five points Likert Scale questions, the respondents' level of agreement with the statements was measured. This method can clearly indicate the agreement of respondents on a scale from 'strongly agree' to strongly disagree'. When Chi square statistical test was run, the "agree and strongly agree" responses were combined into one category and the "disagree and strongly disagree" were combined into one category. Then, there is only three categories of responses which is agree, disagree and neither for data analysis (Chi-square test).

3.4 Evaluation of the characteristics of footpaths and footpath maps in Ishikari Subprefecture

The characteristics of the 24 footpaths in Ishikari Subprefecture were evaluated using DEM, land use data in order to know whether it is fulfill the preferable characteristics of footpaths by the different age groups. Whereas, the characteristics of footpath maps was evaluated by the existing footpath maps. Then, the 24 footpaths data sheets which included a slope change map, elevation graph and land use composition were created using DEM and land use data.

3.4.1 Spatial data acquired and sources

Footpaths spatial data in Ishikari Subprefecture were collected by digitizing from the available footpath maps. For footpath that don't have footpath map, footpaths data were collected by using Global Positioning System (GPS) device. Then, footpaths data were stored in an ArcGIS shapefile (feature dataset). Digitizing is considered cost and time efficiency compare with field GPS data collection. The footpath GPS data collected in the fields were time consuming.

The 10 m Digital Elevation Model (DEM) data were acquired from the Geospatial Information Authority of Japan (GSI). The 100 m land use mesh data (2014) and GIS point feature data of public transportation such as bus stops and train stations were acquired from the National Land Numerical Information. The GIS data set (point feature) of the location of toilets and sightseeing places (interesting points) such as museum, parks, farms and shops with delicious local foods along the footpaths in Ishikari Subprefecture were created by using ArcMap 10.3.

Before using those data for further analysis process, all of the data layers were defined and projected as Projected Coordinate System WGS 1984 UTM Zone 54N. The summary of spatial data used in this study to evaluate the characteristics of footpaths in Ishikari Subprefecture was listed as table 3.1.

Table 3.1 Summary of spatial data used in this study

No	Data Type	Spatial Resolution	Year Production	Source	Usage
1	Footpaths	/	2016	Digitizing from available footpath maps	To show the location of footpaths in polyline
2	Digital Elevation Model (DEM) data	10 meters	31 October 2016	Geospatial Information Authority of Japan (GSI)	To calculate distance, elevation and slope change of 24 footpaths
3	Land use mesh data	100 meters	2014	National Land Numerical Information	To calculate land use composition of 24 footpaths
4	Train stations	/	2015	National Land Numerical Information	To show the point location of train station
5	Bus stops	/	2010	National Land Numerical Information	To show the point location of bus stops
6	Sightseeing places	/	2016	Digitizing from available footpath maps	To show the point location of sightseeing places
7	Toilets	/	2016	Digitizing from available footpath maps	To show the point location of toilets

3.4.2 Digital Elevation Model (DEM)

The statement of "length of footpath" was evaluated by using DEM data. 10 meter DEM data of Ishikari Subprefecture were acquired from the Geospatial Information Authority of Japan (GSI). First, Add Surface Information Tool in 3D Analyst Toolbox of ArcMap was used to calculate the length (surface length), elevation (max, min and mean) and slope (max, min and average) of the 24 footpaths in Ishikari Subprefecture.

Then, footpath's slope change map in Ishikari Subprefecture was created from DEM. First, the raster data (DEM) were converted to UTM projected coordinates by project raster in the Data Management Toolset. The DEM was projected as Projected Coordinate System WGS 1984 UTM Zone 54N. The slope map was created by the Slope tool in the spatial analyst toolset. Then, raster track of the 24 footpaths in Ishikari Subprefecture was created by the slope map. Extract by mask tool in the Spatial Analyst Toolset was used and the slope change across the 24 footpaths in Ishikari Subprefecture was created.

Then, stack profile tool in Functional Surface toolbox of ArcGIS 10.3 was used and DEM elevation data in table format along the footpaths in Ishikari Subprefecture were extracted. Then, elevation graph of the 24 footpaths was created in GIS.

3.4.3 Land use data (2014)

The statement of "theme of footpath" was evaluated by calculating the land use composition along the footpaths. First, 100 m buffer along the footpath polylines feature data were created in ArcMap 10.3. Layer of buffer along the footpaths were intersected with the 2014 land use data using GIS. After intersect analysis, the area of different type of land uses in the 100 m buffer along the footpaths was calculated by Calculated Geometry Tool in Attribute table. The area of the land uses composition along the 24 footpaths in this study was measured in percentage.

Lastly, the slope change maps, elevation graphs, land use composition pie charts and surface information of the 24 footpaths in this study were created and used for the creation of footpaths' data sheets.

The statement of "type of footpath surface" was evaluated by calculating the Simpson's and Shannon-Wiener Land use Diversity Index. Land use Diversity Index were calculated to determine the level of land use diversity along the 100m buffer along the footpaths in Ishikari Subprefecture. If the land use diversity is high mean there is a variety of the footpath surface because the footpath routes passing through different type of footpath surface.

i) Simpson's Diversity Index (Barcelona Field Studies Centre, 2016)

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

D = Simpson's Diversity Index
n = The total number of particular land use types
N = The total number of land use types

ii) Shannon-Wiener Diversity Index (Magurran, 2004)

$$H' = -\sum pi \ln pi$$

pi = Proportion of land use (n/N)
ln = Natural logarithm

3.4.4 Existing footpath maps

The statement of "type of footpaths", "place for start/ finish points of footpaths" and "Which geographical information to be important included in the footpath map" were evaluated based on the existing footpath map. The characteristics of the 24 footpath maps were evaluated based on whether regional resources and facilities (public transportation, sightseeing places, toilets and rest places) are mapped in existing footpath maps.

3.5 New footpath route planning for young adults around Oasa Station, Ebetsu using ArcGIS Network Analyst

3.5.1 Factors for footpath route planning

The factors for footpath routes planning in this study was identified after data analysis of questionnaire survey from different age groups about their preferable characteristics of footpaths and footpath maps.

3.5.2 Spatial data acquired and sources

The road spatial data (polylines feature) were downloaded from OpenStreetMap. Whereas, point location of sightseeing places, toilets, Oasa JR station in Ebetsu were obtained from Google image. Then, shapefile of those point locations were created and stored in ArcGIS. Point location of train stations and bus stops in shapefile were downloaded from the National Land Numerical Information. Geospace CDS (Aerial image) was used as background map for visualizing.

The data showed in Table 3.2 were acquired for performing network analyst and new footpath route for the young adults group around Oasa station, Ebetsu were planned and created. Before using those data for further analysis process, all of the data layers were defined and projected as Projected Coordinate System WGS 1984 UTM Zone 54N.

Table 3.2 Spatial data acquired and sources for footpath route planning

No	Data Type	Year Production	Source	Usage
1	Oasa Eki Footpaths	2016	Digitizing from available footpath maps	To show the location of existing footpath in polyline
2	Road	2016	OpenStreetMap	To create Road network dataset for network analyst
3	Sightseeing places, parks,	2016	Ebetsu Tourism Association	To show the location of sightseeing places, parks, universities and foods and

	universities and foods and drinks			drinks along the footpath
4	Toilets	2016	Digitizing from aerial image	To show the point location of sightseeing places along the footpath
5	Parks	2016	Digitizing from aerial image	To show the polygon location of parks
6	Agricultural areas	2016	Digitizing from aerial image	To show the polygon location of agricultural areas
7	Train Stations	2015	National Land Numerical Information	To show the point location of Oasa JR Station
8	Bus stops	2010	National Land Numerical Information	To show the point location of bus stops around Oasa JR Station

3.5.3 Network Analyst

The Road Network Dataset was created in ArcCatalog by road spatial data. The new network dataset was added to ArcCatalog along with the system junctions feature class and junctions. Then, the Road Network Dataset was added to the ArcMap and Network analysis layer was created to run the analysis.

Before the network analysis run, the stops to be visited by a route were added by the Create Network Location Tool on the Network Analyst toolbar. After the location of sightseeing places preferred by young adults were selected, the parameters for the analysis was set up which is the impedance was set to length (meters).

Then, the "solve" button on the Network Analyst toolbar was clicked and the optimal footpath route that preferred by young adults was computed. Lastly, the new footpath route planned by Network Analyst function was saved as feature classes using the Export Data. Then, the best and quickest footpath routes for young adults that pass through different sightseeing places and recreational facilities near the Oasa JR station were planned using Network Analyst function and a map was created using ArcMap.

CHAPTER 4 RESULTS

4.1 Preferable characteristics of footpaths and footpath maps by the different age groups using questionnaire survey

In the 21 August 2016, 300 questionnaires (Appendix A) were distributed at the footpath walking event that held in Teine Area of Sapporo City. However, there are 94 questionnaires were returned. The rate of response of this questionnaire survey was 31.33% only. Although the rate of response is quite low but according to Burgess (2001), the usual rate of response is around 20%.

4.1.1 The respondents' background, walking behavior and purpose of using footpaths by the different age groups

Table 4.1 summarizes the respondents' background with the different age groups. There were total 94 respondents which are 58 male respondents and 36 female respondents. In this questionnaire survey, the respondents were categorized into three age groups which is young adults (15-39 years old), middle-aged (40-59 years old) and older adults (above 60 years old). The older adult group has the highest number of responses which is 58 of the respondents. Young adults and middle-aged groups only have 21 and 15 of respondents respectively. There were 66 respondents come from cities within Ishikari Subprefecture and 18 of the respondents were come from cities outside Ishikari Subprefecture. There are also 8 of respondents come from another city out of Hokkaido such as Osaka City, Fukuoka City, Kitakyushu City and Ibaraki City.

Table 4.1 The respondents' background by the different age groups

Statements	Age Groups						Total	
	Young Adults		*Middle-aged*		*Older Adults*			
	%	n	%	n	%	n	%	n
Gender								
Male	57.1	12	60.0	9	63.8	37	61.7	58
Female	42.9	9	40.0	6	36.2	21	38.3	36
Total	100.00	21	100.0	15	100.0	58	100.0	94

City of residence								
Cities within Ishikari Subprefecture	15.0	3	60.0	9	94.7	54	71.7	66
Cities outside Ishikari Subprefecture	65.0	13	13.3	2	5.3	3	19.6	18
Cities outside of Hokkaido	20.0	4	26.7	4	0.0	0	8.7	8
Total	100.0	20	100.0	15	100.0	57	100.0	92

The walking behavior was measured by asking respondents about "How often do you use the footpath", "How do you prefer to use the footpaths?" and "Purpose of using Footpath". For the statement "How often do you use the footpath" and "How do you prefer to use the footpaths?", Chi square analysis found that there were not statistically significant difference ($p \geq 0.05$) among the different age groups. The calculation of the Chi square test was shown in Appendix B. This showed that different age groups have the same perspective towards each statement that showed as below. There were 42.6% of the respondents were footpath frequent user which using footpath once per month and more than two times per month. However, 27.7% of the respondents also showed that they have never used footpath before and 29.8% of the respondents showed they use footpaths sometime only such as once per year, half year and every three months (Figure 4.1). There were 50.7% of the respondents from the different age groups usually use the footpath with their friends and family. However, 21.3% of the respondents also prefer using the footpath alone and 28.0% of the respondents join footpath walking groups/ tours. Among the different age groups, young adult group who usually uses footpath with friends and family have the highest percentage which is 58.8% (Figure 4.2).

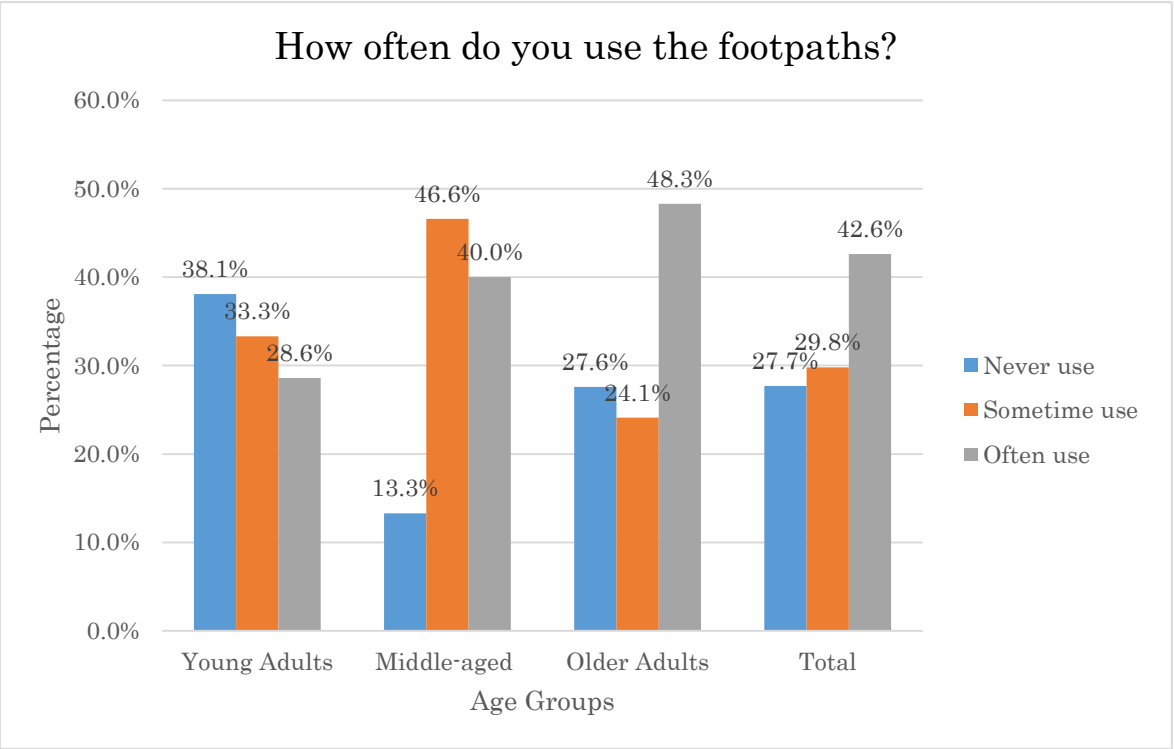


Figure 4.1 Respondents' response on the statement "How often do you use the footpaths?" by the different age groups. (n = 94, p value = 0.238)

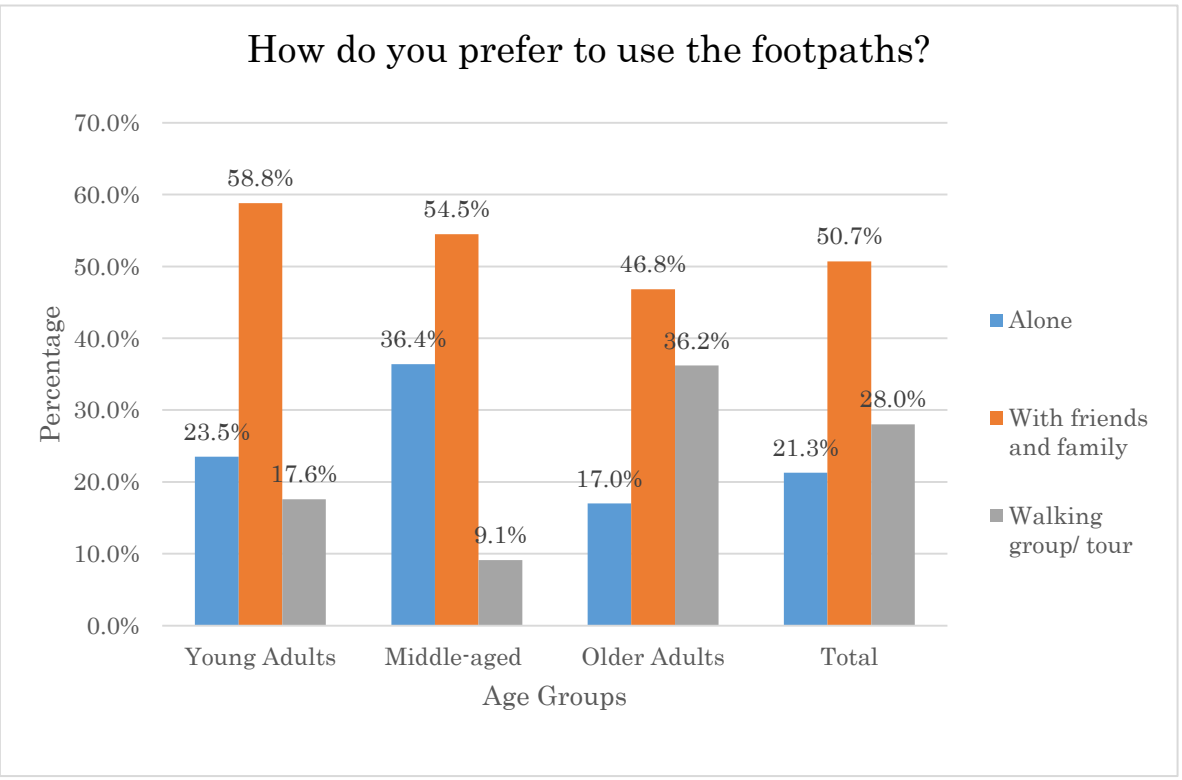


Figure 4.2 Respondents' response on the statement "How do you prefer to use the footpaths?" by the different age groups. (n = 75, p value = 0.269)

For the statement "Purpose of using Footpath", respondents were allowed to do multiple response. Each variable was calculated in percent to show which variable has the highest percentage. The arrangement of the variables in this statement from the highest to the lowest is as follows, exercise or training (66.0%) > recreation (57.4%) > interaction (35.1%) > to experience the life of local people (20.2%) > environmental education (12.8%) (Table 4.2).

Table 4.3 showed the Jaccard similarity among the five purposes of using footpaths ranged between 0.07 and 0.40. Calculation of the Jaccard Similarity Index was showed in Appendix C. The purpose of using footpaths which is exercise or training and recreation were closely related (40.0% similarity) and it is preferred by different age groups in this study. Therefore, from the table 4.2 and 4.3, most of the purpose of using footpaths by respondents was exercise or training and recreation.

Table 4.2 Respondents' response on the statement "purpose of using footpaths" (n=180)*

Statement: Purpose of using footpaths	**Age Groups**			**Total**
	Young Adults	***Middle-aged***	***Older Adults***	
Recreation	33.3%	60.0%	65.5%	57.4%
Exercise/ Training	23.8%	66.7%	81.0%	66.0%
To experience the life of local people	19.0%	40.0%	15.5%	20.2%
Interaction	33.3%	33.3%	36.2%	35.1%
Environmental Education	14.3%	26.7%	8.6%	12.8%

Table 4.3 Jaccard similarity between five purposes of using footpaths

Jaccard Similarity	Recreation	Exercise/ Training	To experience the life of local people	Interaction	Environmental Education
Recreation	1				
Exercise/ Training	**0.40**	1			
To experience the life of local people	0.22	0.11	1		
Interaction	0.38	0.22	0.30	1	
Environmental Education	0.16	0.07	0.15	0.22	1

4.1.2 Preferable characteristics of footpaths by the different age groups

For the statement "Preferable themes of footpaths", respondents were allowed to do multiple response. Each variable was calculated in percent to show which variable has the highest percentage. The arrangement of the variables in this statement from the highest to the lowest is as follows, forests (73.4%) > sightseeing places (69.2%) > delicious local foods (54.3%) > wetlands or grasslands (47.9%) > agricultural lands (35.1%) > urban areas (21.3%) > universities (13.8%) (Table 4.4).

Table 4.5 showed the Jaccard similarity among the seven themes of footpaths ranged between 0.12 and 0.54. Calculation of the Jaccard Similarity Index was showed in Appendix C. Footpaths' theme with forest and sightseeing places as well as forests and wetlands, grasslands were closely related (54% similarity) and it is preferred by different age groups in this study. Therefore, from the table 4.3 and table 4.4, most of the respondents preferred footpaths walk through forests, sightseeing places, delicious local foods and wetlands or grasslands.

Table 4.4 Respondents' response on the statement "Preferable themes of footpath" (n=296)*

Statement: Preferable themes of footpath	**Age Groups**			**Total**
	Young Adults	**Middle-aged**	**Older Adults**	
Sightseeing places	52.4%	66. 7%	75.9%	69.2%
Forests (Primary, secondary forest, afforested area)	57.1%	60.0%	82.8%	73.4%
Agricultural lands (paddy, rice fields)	33.3%	46. 7%	32.8%	35.1%
Wetlands, Grasslands	38.1%	60.0%	48.3%	47.9%
Delicious Local Foods	57.1%	60.0%	51.7%	54.3%
Urban Areas	38.1%	20.0%	15.5%	21.3%
Universities	9.5%	20.0%	13.8%	13.8%

Table 4.5 Jaccard similarity between seven themes of footpaths

Jaccard Similarity	Sight-seeing places	Forests	Agricultural lands	Wetlands, Grasslands	Delicious local foods	Urban areas	Universities
Sightseeing places	1						
Forests	**0.54**	1					
Agricultural lands	0.36	0.36	1				
Wetlands, Grasslands	0.41	**0.54**	0.50	1			
Delicious local foods	0.41	0.46	0.35	0.41	1		
Urban areas	0.23	0.13	0.13	0.16	0.20	1	
Universities	0.16	0.15	0.24	0.14	0.12	0.14	1

For the statement “Preferable length of footpath”, Chi square analysis found that there were statistically significant difference ($p < 0.05$) among the different age groups. The calculation of the Chi square test was shown in Appendix B. This also showed that different age groups have different perspective towards their preferable length of the footpath. For young adult groups, they preferred footpath’s length around 3-5 km. However, the middle-aged and older adult groups preferred 5-7 km and 7-10 km length of footpath respectively (Figure 4.3).

For the statement “preferable type of footpath”, “preferable place for start/ goal of footpath?” and “preferable type of footpath surface”, Chi square analysis found that there were not statistically significant difference ($p \geq 0.05$) among the different age groups. The calculation of the Chi square test was shown in Appendix B. This showed that different age groups have the same perspective towards each statement that showed as below.

For the statement “preferable type of footpath”, 82.4% of the respondents showed that their preferable footpath is loop (circular). Whereas, there were only 17.6% of the respondents prefer linear (point to point) type of footpaths (Figure 4.4).

For the statement “preferable place for start/ finish points of footpath?”, 85.3% of the respondents showed that they prefer train or bus stations become a start or goal of footpath. There was only 4.0% of the respondents showed that preferred universities as the start and the goal of footpath. For the “others”, there was only 1.3% of the respondents showed that they prefer citizen center as the start and the goal of footpath (Figure 4.5).

For the statement “preferable type of footpath surface”, 70.8% of the respondents showed that they preferred mixture of several types of footpath surface. Whereas, there were 25.8% of the respondents showed that they prefer walking in nature areas such as soil road and grassland. There was only 3.4% of the respondents showed that they prefer walking in urban areas such as gravel road and asphalt (Figure 4.6). Table 4.6 showed the summary of preferable characteristics of footpaths by the different age groups.

Table 4.6 Summary of preferable characteristics of footpaths by the different age groups

Statements	Age Groups			Total	p-value
	Young Adults	*Middle-aged*	*Older Adults*		
1. Preferable length of footpath	3-5 km (42.9%)	5-7 km (42.9%)	7-10 km (43.6%)	5-7 km (37.8%)	0.001
2. Preferable type of footpath	Loop (circular) (82.4%)				0.256
3. Preferable place for start/ finish points of footpath	Train/ Bus stations (85.3%)				0.469
4. Preferable type of footpath surface	Mixture of several types (soil road, grassland; gravel road and asphalt) (70.8%)				0.919

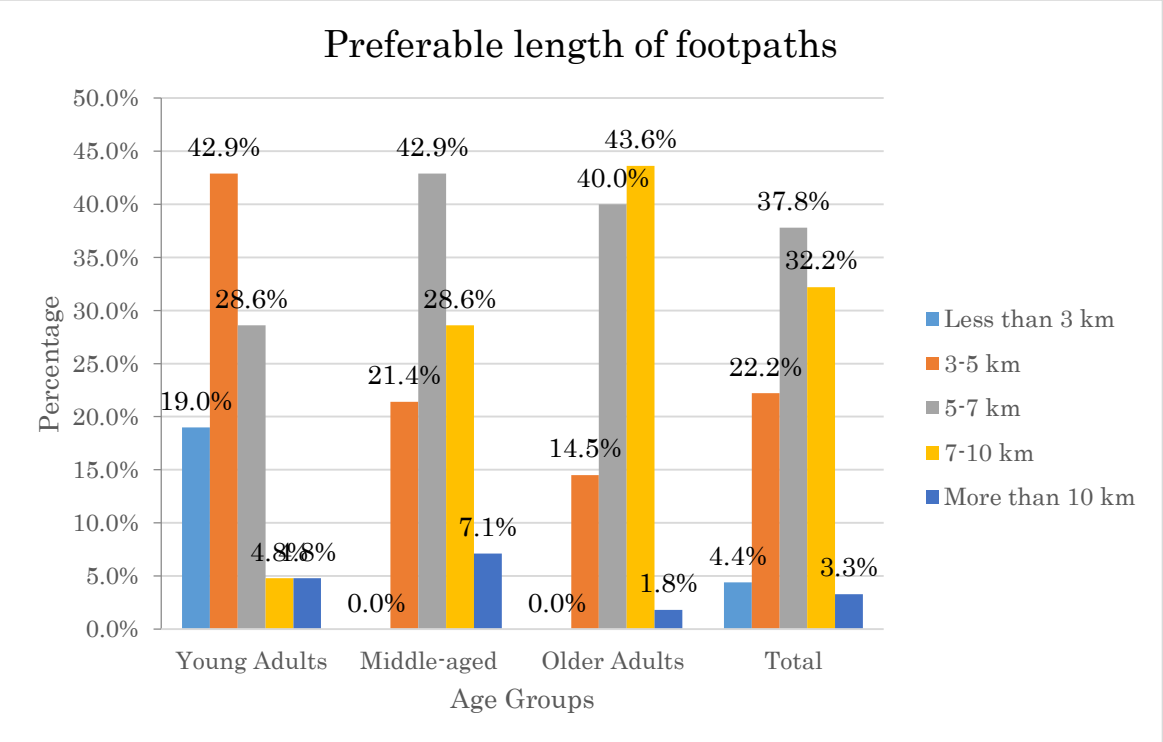


Figure 4.3 Respondents' response on the statement "Preferable length of footpaths" by the different age groups (n = 90, NA = 4, p value = 0.001)

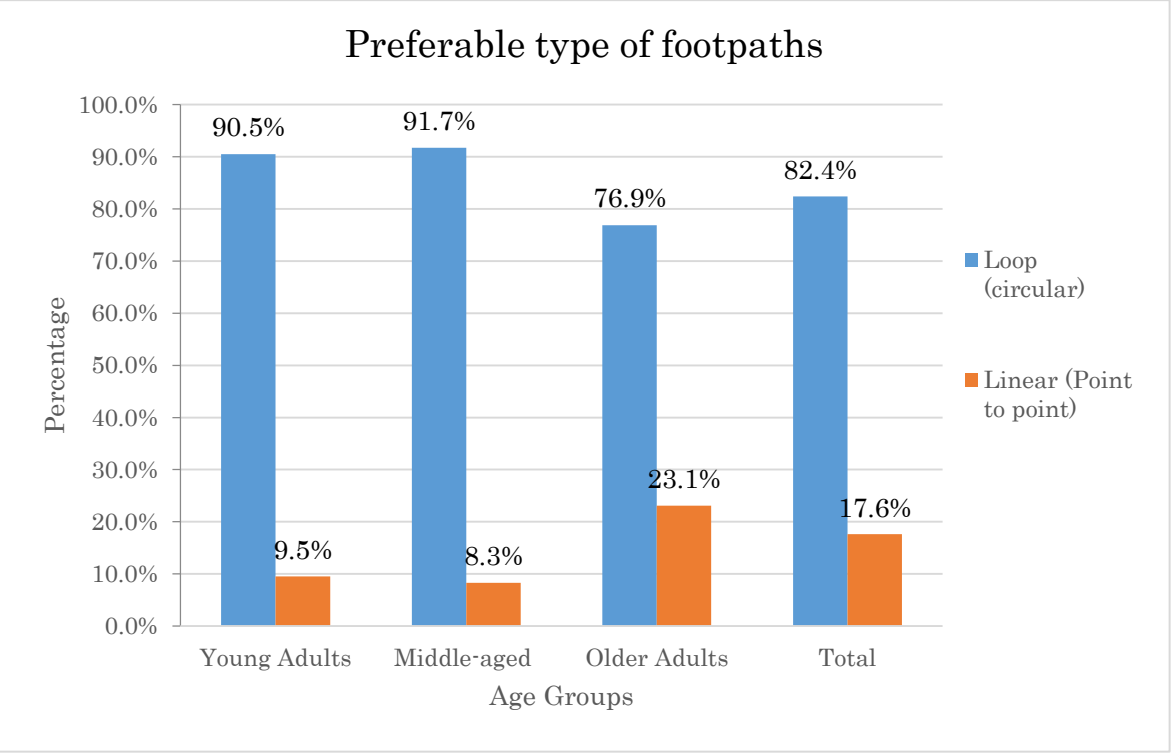


Figure 4.4 Respondent's response on the statement "Preferable type of footpaths" by the different age groups (n = 85, NA = 15, p value = 0.256)

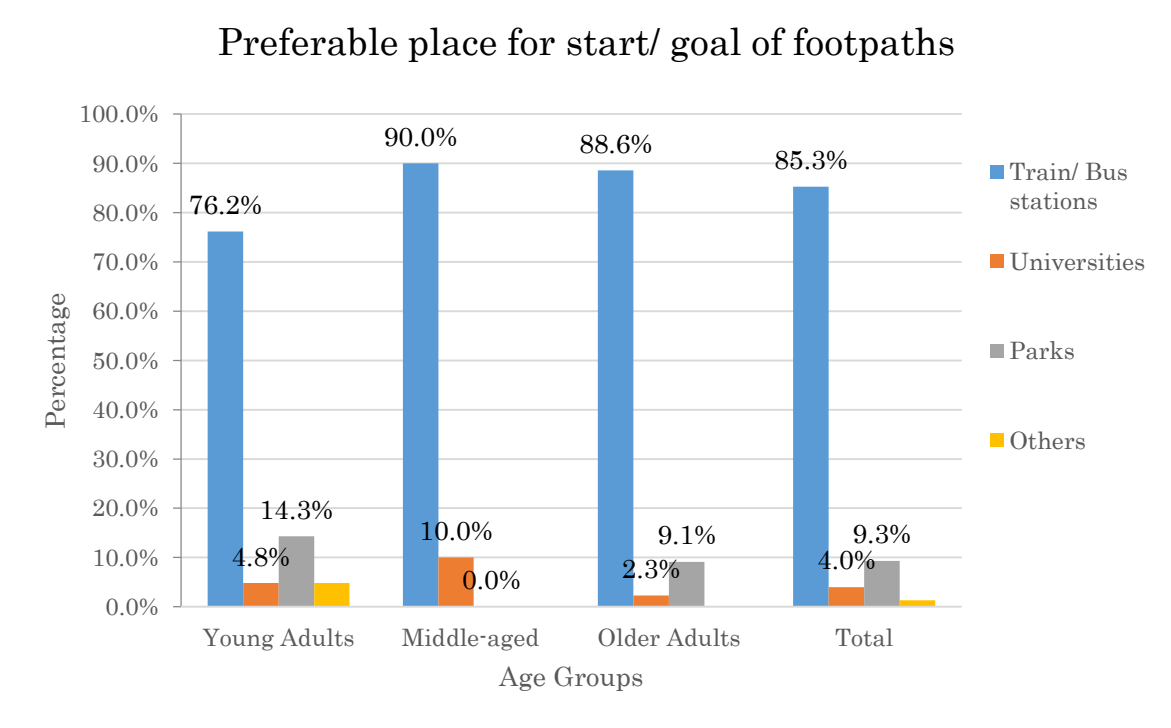


Figure 4.5 Respondent's response on the statement "Preferable place for start/ goal of footpaths" by the different age groups (n = 75, NA = 19, p value = 0.469)

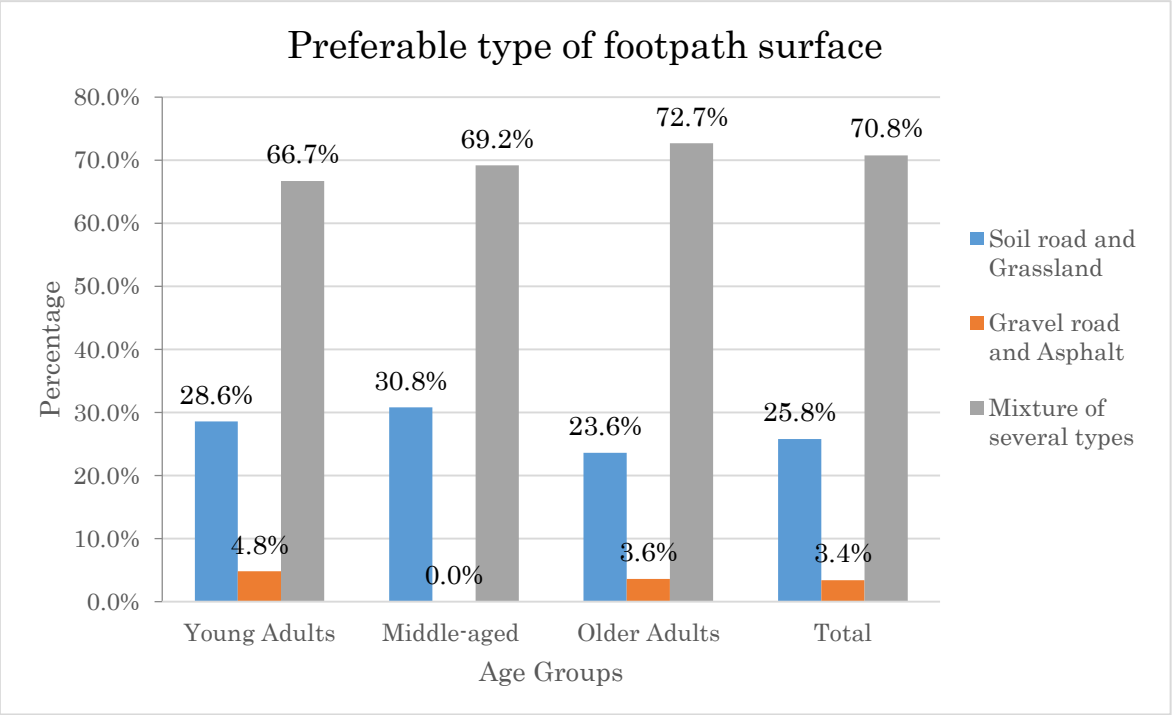


Figure 4.6 Respondent's response on the statement "Preferable type of footpath surface" by the different age groups (n = 89, NA = 5, P value = 0.919)

Table 4.7 showed the variables of frequency (never, sometime and often use) of footpath users using footpath and preferable length of the footpath by the different age groups were studied. From the result, the footpath users with different experience (frequency of footpath users) don't affect their preferable length of the footpath. The preferable length of footpath only showed different when in different age groups. Young adults with different experiences in using footpaths showed that they preferred footpath length with 3-5 km only. For middle-aged and older adults groups with different experience, they preferred footpath length with 5-7 km only.

Table 4.7 Preferable length of footpath by different age groups with frequency of footpath users using footpaths

	Never use	Sometime use	Often use
Young Adults	3-5 km	3-5 km	3-5 km
Middle- aged	5-7 km	5-7 km	5-7 km
Older adults	5-7 km	5-7 km	5-7 km

4.1.3 Preferable characteristics of footpath map and sources to get the footpath maps and information by the different age groups

For the statement "Which geographical information important to be included in the footpath map", respondents are allowed to do multiple response. Each variable was calculated in percentage to show which variable has the highest percentage. The arrangement of the variables in this statement from the highest to the lowest is as follows, toilets (88.3%) > sightseeing places (78.7%) > resting places (77.7%) > bus stops or train stations (59.6%) > car parking lots (23.4%) > convenient stores (16.0%) (Table 4.8).

Table 4.8 Respondents' response on the statement "Which geographical information to be important included in the footpath map" (n=323)*

Statement: Which geographical information important to be included in the footpath map?	**Age Groups**			**Total**
	Young Adults	**Middle-aged**	**Older Adults**	
Toilets	90.5%	80.0%	89.7%	88.3%
Convenient stores	23.8%	26.7%	10.3%	16.0%
Resting places	66.7%	66.7%	84.5%	77.7%
Car parking lots	23.8%	53.3%	15.5%	23.4%
Bus stops/ train stations	38.1%	53.3%	69.0%	59.6%
Sightseeing places	57.1%	73.3%	87.9%	78.7%

Table 4.9 showed the Jaccard similarity among the six geographical information to be important included in the footpath maps ranged between 0.14 and 0.73. Calculation of the Jaccard Similarity Index was showed in Appendix C. The geographical information which is toilets and resting places as well as toilets and sightseeing places were closely related (73% similarity) and it is preferred by different age groups in this study. Therefore, from the table 4.8 and 4.9, most of the respondents stated that the location of toilets, resting places and sightseeing places were important included in the footpath maps.

Table 4.9 Jaccard similarity between six geographical information to be important included in the footpath maps

Jaccard Similarity	Toilets	Convenient stores	Resting places	Car parking lots	Bus stops/ train stations	Sightseeing places
Toilets	1					
Convenient stores	0.17	1				
Resting places	**0.73**	0.14	1			
Car parking lots	0.22	0.32	0.22	1		
Bus stops/ train stations	0.58	0.18	0.54	0.28	1	
Sightseeing places	**0.73**	0.14	0.63	0.17	0.49	1

For the statement "Preferable type of footpath Map?", Chi square analysis found that there were not statistically significant difference ($p \geq 0.05$) among the age groups. The calculation of the Chi square test was shown in Appendix B. This showed that different age groups have the same perspective to this statement. 78.7% of the respondents prefer paper map. Whereas, there are only 2.1 % of respondents prefer using digital map. 19.1% of the respondents showed that they prefer both types of map (Figure 4.7). Table 4.4 showed the summary of preferable characteristics and the type of footpath maps by the different age groups.

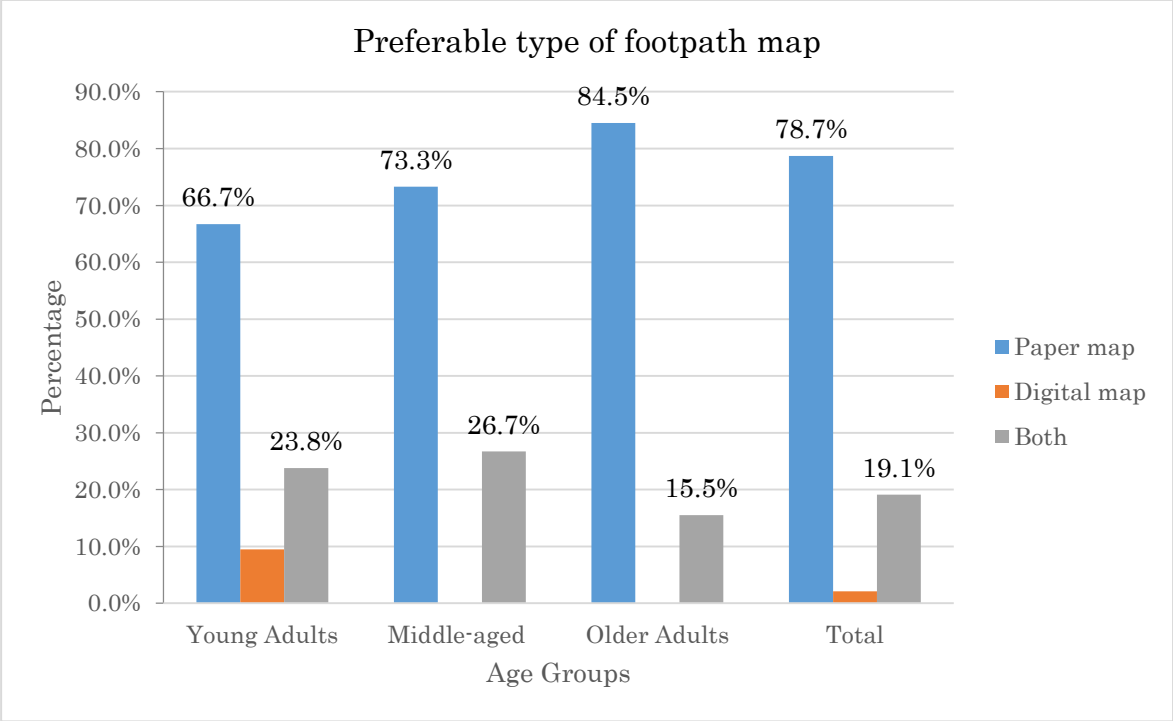


Figure 4.7 Respondent's response on the statement "Preferable type of footpath map" with the different age groups (n = 94, P value = 0.068)

For the statement "Usually where you get the footpath map and information", Chi square analysis found that there were statistically significant difference ($p < 0.05$) among the age groups. The calculation of the Chi square test was shown in Appendix B. This showed that different age groups usually get the footpath map and information from different source. For young adults and middle-aged group, 60.0% and 50.0% of them received information about footpaths from the internet or footpath website respectively. However, for older adult group, 65.9% of them get footpath information from the walking tours (Figure 4.8).

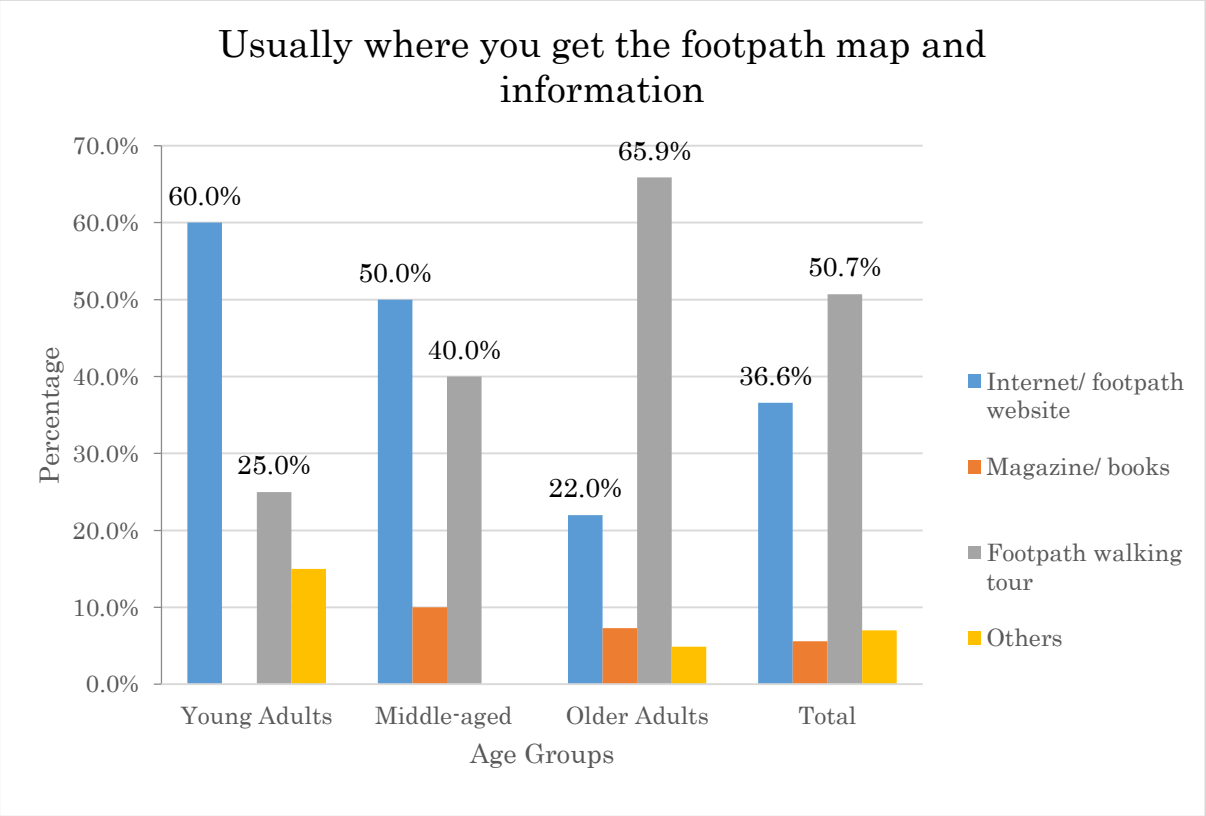


Figure 4.8 Respondent's response on the statement "Usually where you get the footpath map and information" with the different age groups (n = 71, NA = 23, p value = 0.020)

4.1.4 The level of agreement of each statement about footpaths and footpath maps by the different age groups

For the statement "Do you agree setting up direction sign and information boards along footpaths are important", "Do you agree need a footpath walking guide when walking along footpath?", "Do you agree you prefer footpath walking and participate in local activities?", "Do you agree you will need a footpath map when walking on a new footpath course?" and "Do you agree that footpath map with a clear theme, pictures and basic information can attract you to use that footpath?", Chi square analysis found that there were not statistically significant difference ($p \geq 0.05$) among the different age groups for the following statements. The calculation of the Chi square test was shown in Appendix B. This showed that the different age groups have the same perspective toward each statement that showed as below. The five point Likert scale responses (strongly agree, agree somewhat, uncertain, disagree somewhat

and strongly disagree) were simplified into three nominal categories such as agree, uncertain and disagree for Chi square test (Appendix B).

For the statement “Do you agree setting up direction sign and information boards along footpaths are important”, there were 78.5% of the respondents from different age groups agree that setting up direction sign and information boards along footpaths are important. Whereas, 11.9% of the respondents from different age groups showed they disagree this statement are important (Figure 4.9).

For the statement “Do you agree need a footpath walking guide when walking along footpath?”, there were 58.5% of the respondents from different age groups agree that need a footpath walking guide when walking along footpath. Whereas, 13.8% of the respondents from different age groups showed that they don't need a footpath walking guide (Figure 4.10).

For the statement “Do you agree you prefer footpath walking and participate in local activities?”, there were 66.0% of the respondents from different age groups agree that they prefer to participate in local activities while the footpath walking. However, 21.3% of the respondents from different age groups also showed that they want footpath walking only (Figure 4.11).

For the statement “Do you agree you will need a footpath map when walking on a new footpath course?”, there were 91.9% of the respondents from different age groups agree that they need a footpath map when walking on a new footpath course. There were only 4.3% of the respondents from different age groups disagree that they need a footpath map when walking on a new footpath course (Figure 4.12).

For the statement “Do you agree that footpath map with a clear theme, pictures and basic information can attract you to use that footpath?”, there were 79.8% of the respondents from the different age groups showed that they agree footpath map with a clear theme, pictures and basic information can attract them to use that footpath. Whereas, there are only 5.3% of the respondents disagree with this statement (Figure 4.13).

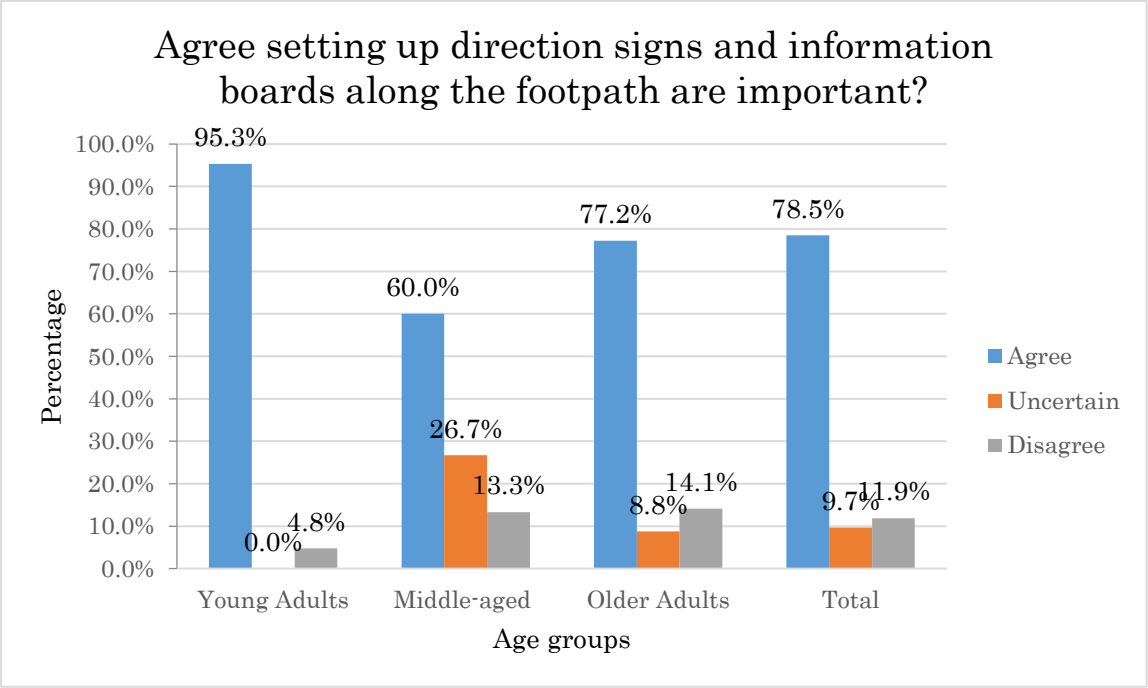


Figure 4.9 Respondent's response on the statement "Agree setting up direction signs and information boards along the footpath are important?" by the different age groups (n = 93, NA = 1, p value = 0.058)

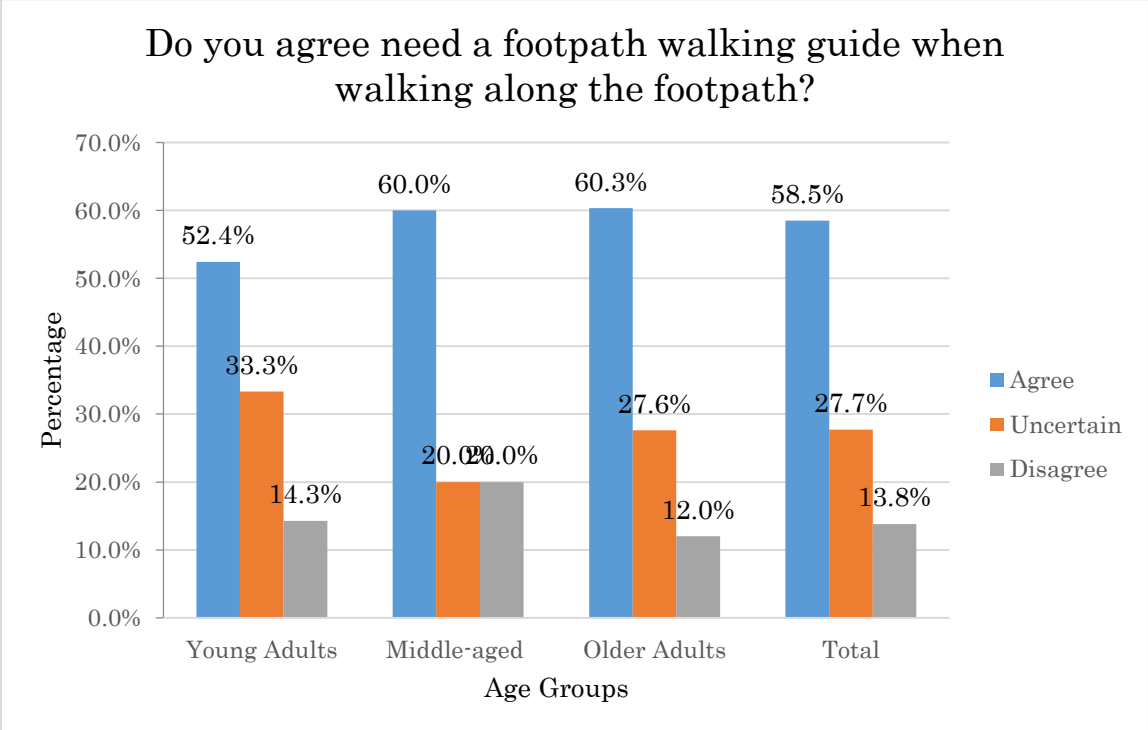


Figure 4.10 Respondents' response on the statement "Do you agree need a footpath walking guide when walking along the footpath?" by the different age groups (n = 94, p value = 0.864)

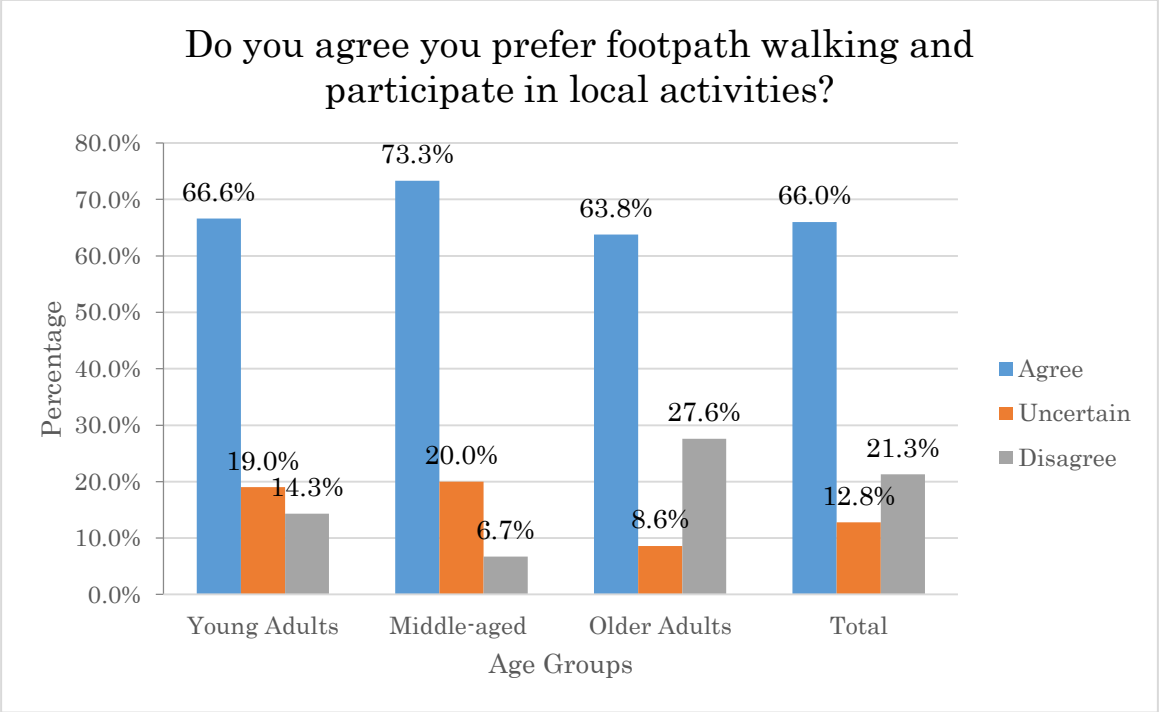


Figure 4.11 Respondent's response on the statement "Do you agree you prefer footpath walking and participate in local activities?" by the different age groups (n = 94, p value = 0.259)

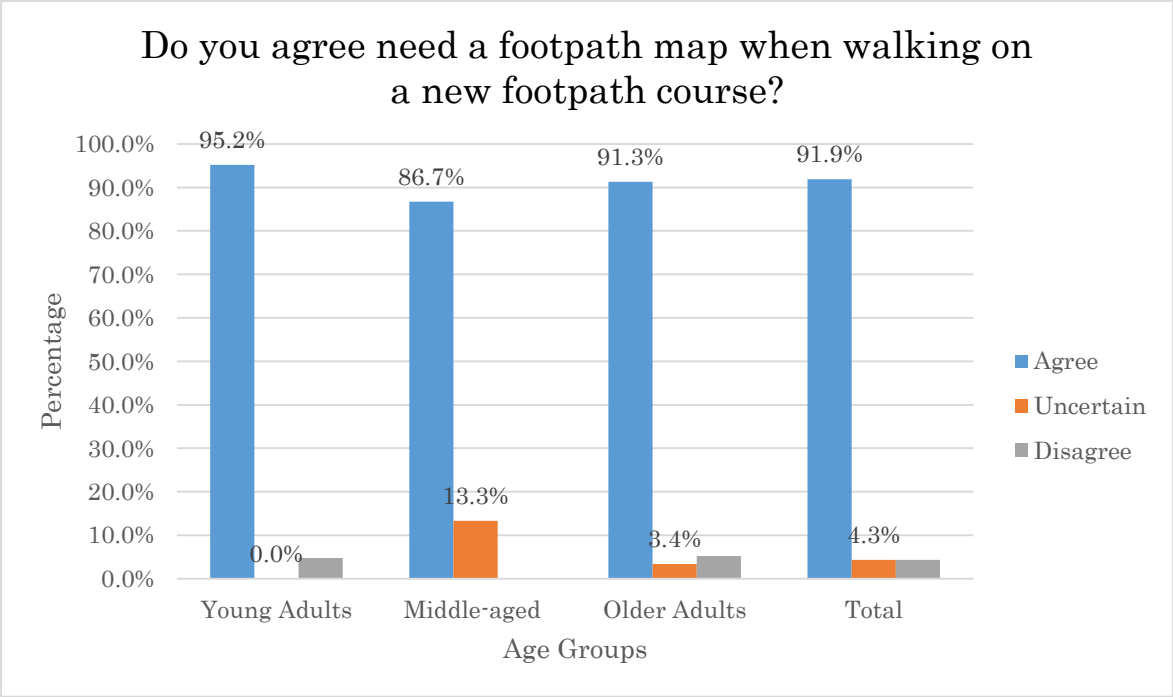


Figure 4.12 Respondent's response on the statement "Do you agree need a footpath map when walking on a new footpath course?" with the different age groups (n = 94, P value = 0.317)

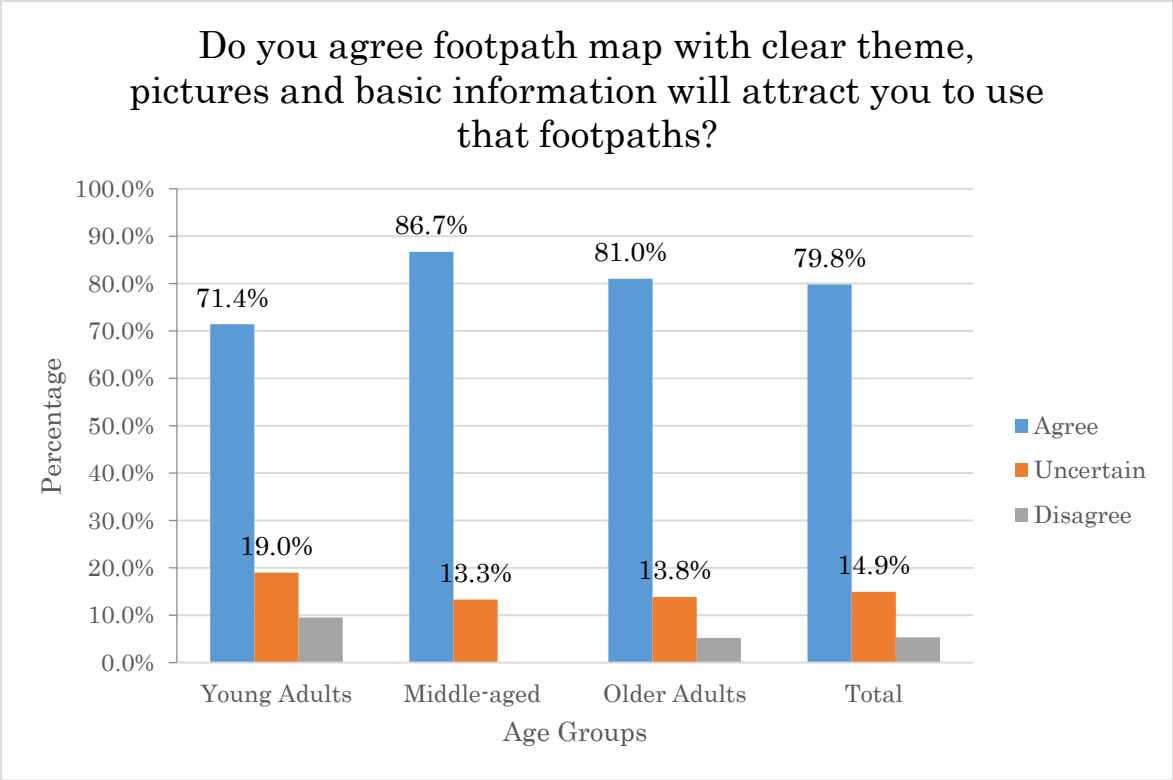


Figure 4.13 Respondent's response on the statement "Do you agree footpath map with clear theme, pictures and basic information will attract you to use that footpaths" with the different age groups (n = 94, P value = 0.718)

4.1.5 Opinions and suggestions about footpaths by the different age groups

Opinions and suggestions about footpaths and footpath maps were collected and categorized into the three age groups. Most of them concern about the safety of footpath users, environmental education elements, facilities along footpaths (information boards, toilets, resting places etc.) and others (Table 4.10).

Table 4.10 Summary of opinion and suggestion of footpaths (Open ended questionnaire)

Age Groups	Responses
Young Adults	Want educational element
	Prefer pocket size footpath map
Middle-age	No footpath maps for certain footpaths. So if there are footpath maps, high school students maybe will have more interest on it
	Need more footpath information along footpath route
Older Adults	Want more footpaths in Hokkaido
	Want to know the name of flowers and plants according to The season
	When new footpath is implemented, must have precautions and emergency plans
	Must have a toilet in the resting points
	Want challenges in information boards preparation, if there are footpath routes and maps
	Want to learn about the history and type of plants around the footpaths. So footpath users can talk with each other and have more fun. They hope that they can learn more about environment
	It would be better if they can rest after 3-4 km footpath walk. They want drinking water in rest points. Especially, walking on sunny days.
	The safety of footpath users must be considered because they share path with bicycle users. Whistles can be used when walking in group, to remind that there are bicycles.

4.2 Evaluation of the characteristics of footpaths and footpath maps in Ishikari Subprefecture

The characteristics of footpaths such as “length of footpath”, “type of footpath”, “place for start/ finish points of footpath”, “type of footpath surface” and “themes of footpath” were evaluated by using DEM data, land use data and footpath maps. Whereas, the characteristics of footpath maps such as “which geographical information to be important included in the footpath map?” were evaluated by using existing footpath maps.

4.2.1 Digital Elevation Model (DEM)

The summary of surface length, max, min of elevation, elevation range, max, min slope and average slope of footpaths in Ishikari Subprefecture were showed in Appendix D.

a) Length (distance) of the footpaths in Ishikari Subprefecture

For the length of the 24 footpaths in Ishikari Subprefecture, the arrangement of the variables from the highest to the lowest is as follows, 5-7 km (11 footpaths) > more than 10 km (5 footpaths) > 7-10km (4 footpaths) > 1-3 km (2 footpaths) and 3-5 km (2 footpaths) (Figure 4.14).

From the result of the questionnaire survey, different age groups preferred different type length of footpaths. Therefore, availability of different length of footpaths in Ishikari Subprefecture can allow footpath users to choose their preferable length of footpaths.

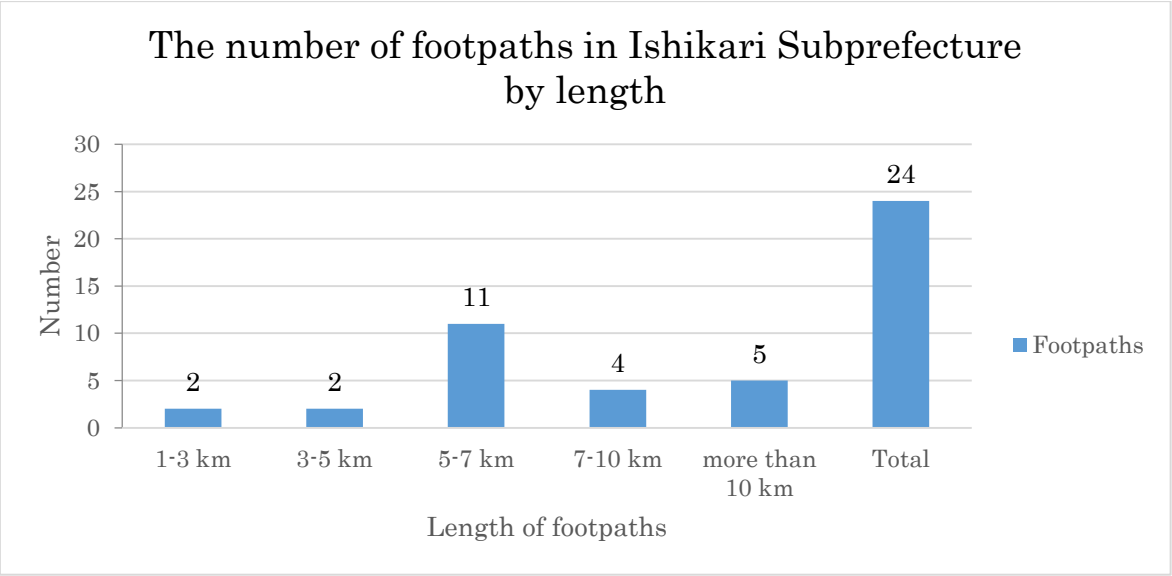


Figure 4.14 The number of footpaths in Ishikari Subprefecture by length

b) Slope change map: steepness of the footpaths

For the maximum slope, the footpaths in Ishikari Subprefecture range from 0.50 to 29.84 degrees. Eniwa Old Shimamatsu Station footpath has the highest maximum slope which is 29.84 degrees (extreme slope). Whereas Soseigawa Yusuichi footpath has the lowest maximum slope which is 0.50 degrees only (Figure 4.15).

The average slope of the footpaths in Ishikari Subprefecture ranges 0.05 to 1.66 degrees which considers footpaths range from flat to very gentle slope (Figure 4.15). The Eniwa Old Shimamatsu Station footpath in Eniwa City has the highest average slope among the footpaths in Ishikari Subprefecture which is 1.66 degrees. Whereas, the Soseigawa Yusuichi footpath in Sapporo City has the lowest average slope among the footpaths in Ishikari Subprefecture which is 0.05 degrees (Figure 4.15). Although the Eniwa Old Shimamatsu Station footpath has the highest average of slope among the footpath in Ishikari Subprefecture, but according to slope steepness index (Table 4.11), it is still considered as footpath with very gentle slope.

Extract by mask tool in the GIS Spatial Analyst Toolset was used in this study because it can visualize the steepness of footpaths. Slope change of the 24 footpath maps with aerial image (CDS) as the background were created (Map 4.1- 4.24). From the slope change map, the steepness of footpath routes was classified into five levels of slope (colors), flat, gentle slope, moderate slope, strong slope and very strong slope.

Then the elevation graph of the 24 footpaths was also created by GIS and showed in footpaths' data sheets. Therefore, the slope change maps and elevation graphs can be used by footpath users in order to know the steepness of the 24 footpaths.

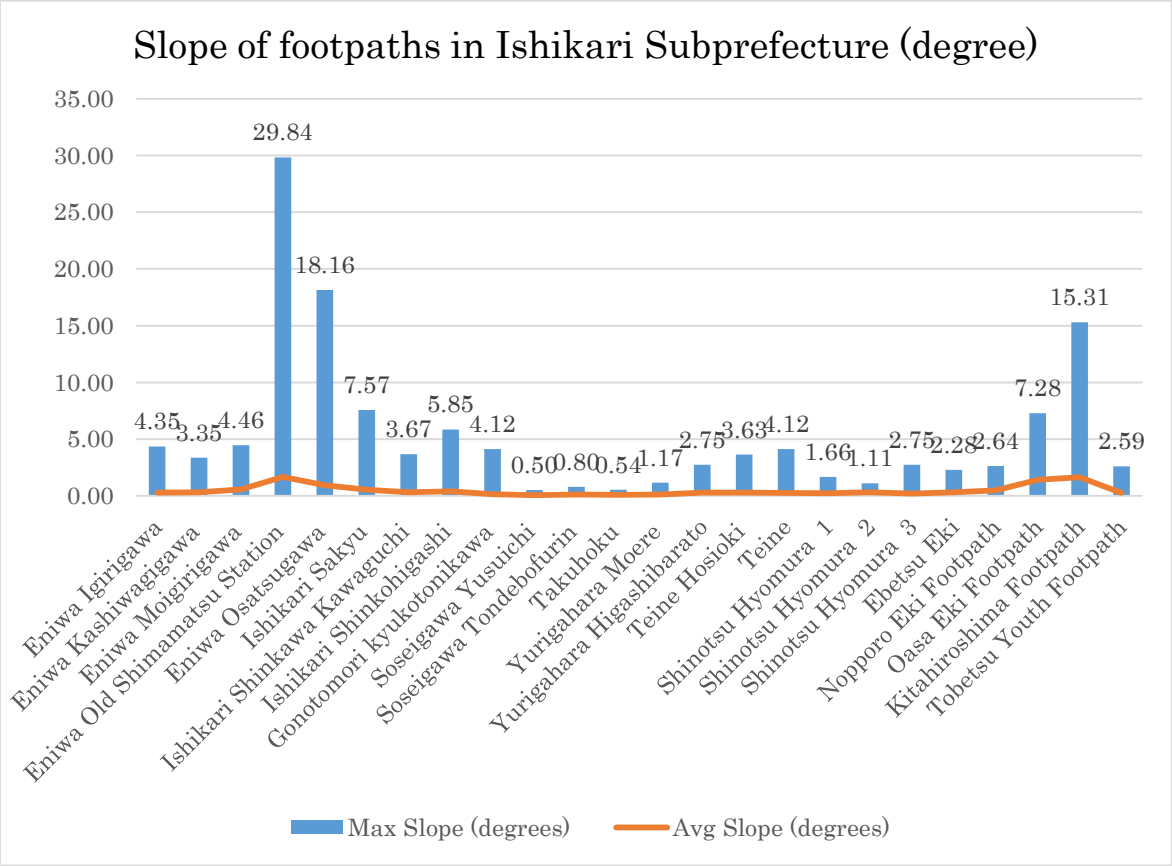


Figure 4.15 The maximum and average slope (steepness) of footpaths in Ishikari Subprefecture

Table 4.11 Slope Steepness Index (Barcelona Field Studies Centre, 2013)

Slope (%)	Degrees of slope	Terminology
0 - 0.5	0 - 0.3	Flat
0.5 - 2	0.3 - 1.1	Nearly flat
2 - 5	1.1 - 3	Very gentle slope
5 - 9	3 - 5	Gentle slope
9 - 15	5 - 8.5	Moderate slope
15 - 30	8.5 - 16.5	Strong slope
30 - 45	16.5 - 24	Very strong slope
45 - 70	24 - 35	Extreme slope
70 - 100	35 - 45	Steep slope
> 100	> 45	Very steep slope

4.2.2 Land use data (2014)

a) Themes of footpath (Land use composition)

The total land use of footpaths in Ishikari Subprefecture was arranged as follows, building areas (34.95%) > agricultural areas (16.68%) > water (12.60%) > forests (10.93%) > open space areas (10.86%) > bare lands (5.93%) > roads and railways (4.51%) > paddy fields (2.13%) > beaches (1.32%) > gold fields (0.10%). Building area was the dominant land use, covering 34.95% of the total area along the footpaths. While, golf fields covered only 0.10% of land use (Figure 4.16). The percentage of 2014 land use of the 24 footpaths in Ishikari Subprefecture were showed in Appendix E.

Land use varied significantly among the footpath. For forest areas, it is varying from 0.1% to 42.7%. The Ishikari Shinkawa Kawaguchi footpath has the highest percentage which is 42.7%, whereas the Gonotomori Kyukotonikawa footpath has the lowest percentage which is 0.1% only. The Yurigahara Moere footpath, Yurigahara Higashibarato footpath and Tobetsu Youth footpath are the footpath that doesn't have forest areas (Figure 4.17).

From the questionnaire survey result, we can know that 73.4% of the respondents preferred footpaths which walk through the forest areas. However, there are only four footpaths in Ishikari Subprefecture that have more than 20% of forest areas along the footpaths which is Ishikari Sakyu (24.8%), Eniwa Osatsugawa (31.8%), Eniwa Old Shimamatsu Station (32.8%) and Ishikari Shinkawa Kawaguchi (42.7%). The number of footpaths that walk through many forest areas are not so many in Ishikari Subprefecture.

For building areas, it is varying from 0.2% to 77.0%. The Nopporo eki footpath has the highest percentage which is 77.0%, whereas Ishikari Shinkohigashi footpath has the lowest percentage which is 0.2%. Ishikari Shinkawa kawaguchi footpath is the only footpath that doesn't have building areas (Figure 4.18).

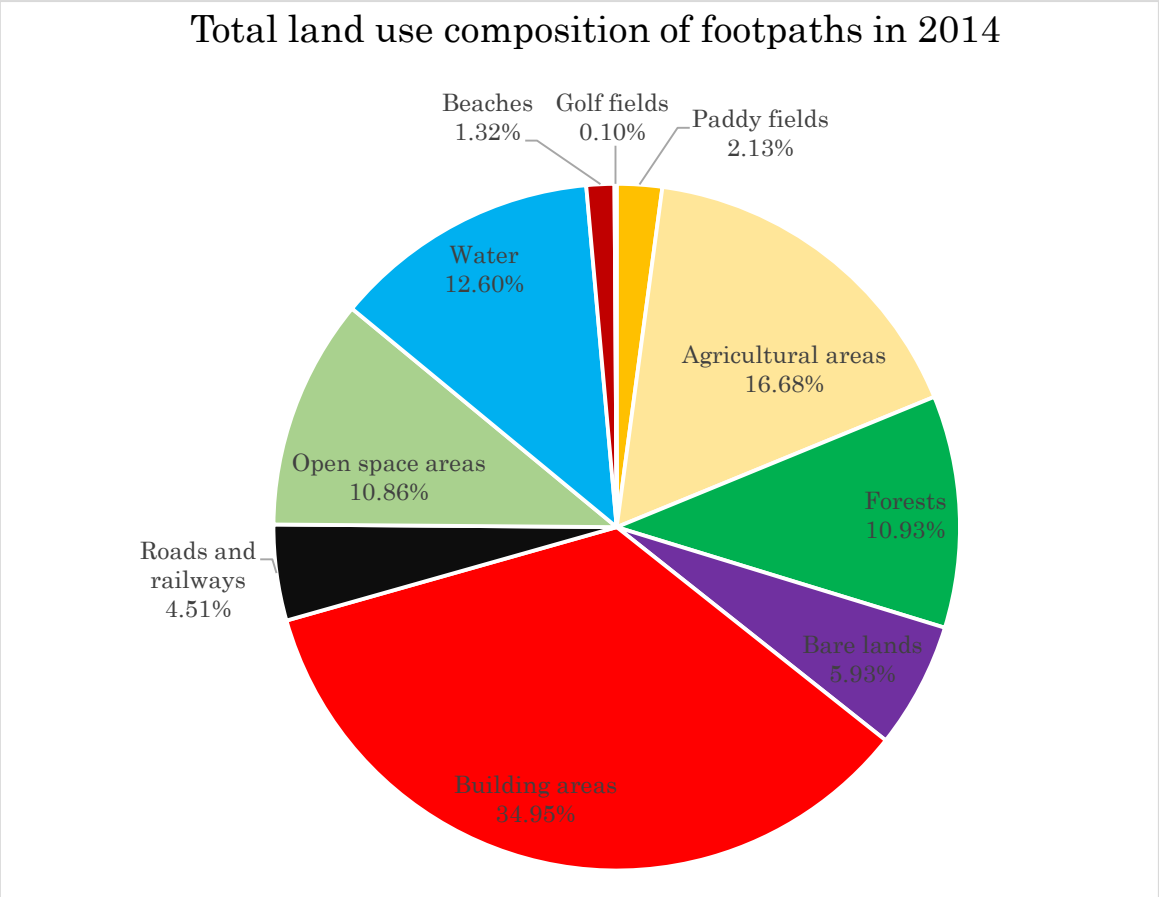


Figure 4.16 Total land use composition of footpaths in Ishikari Subprefecture, 2014

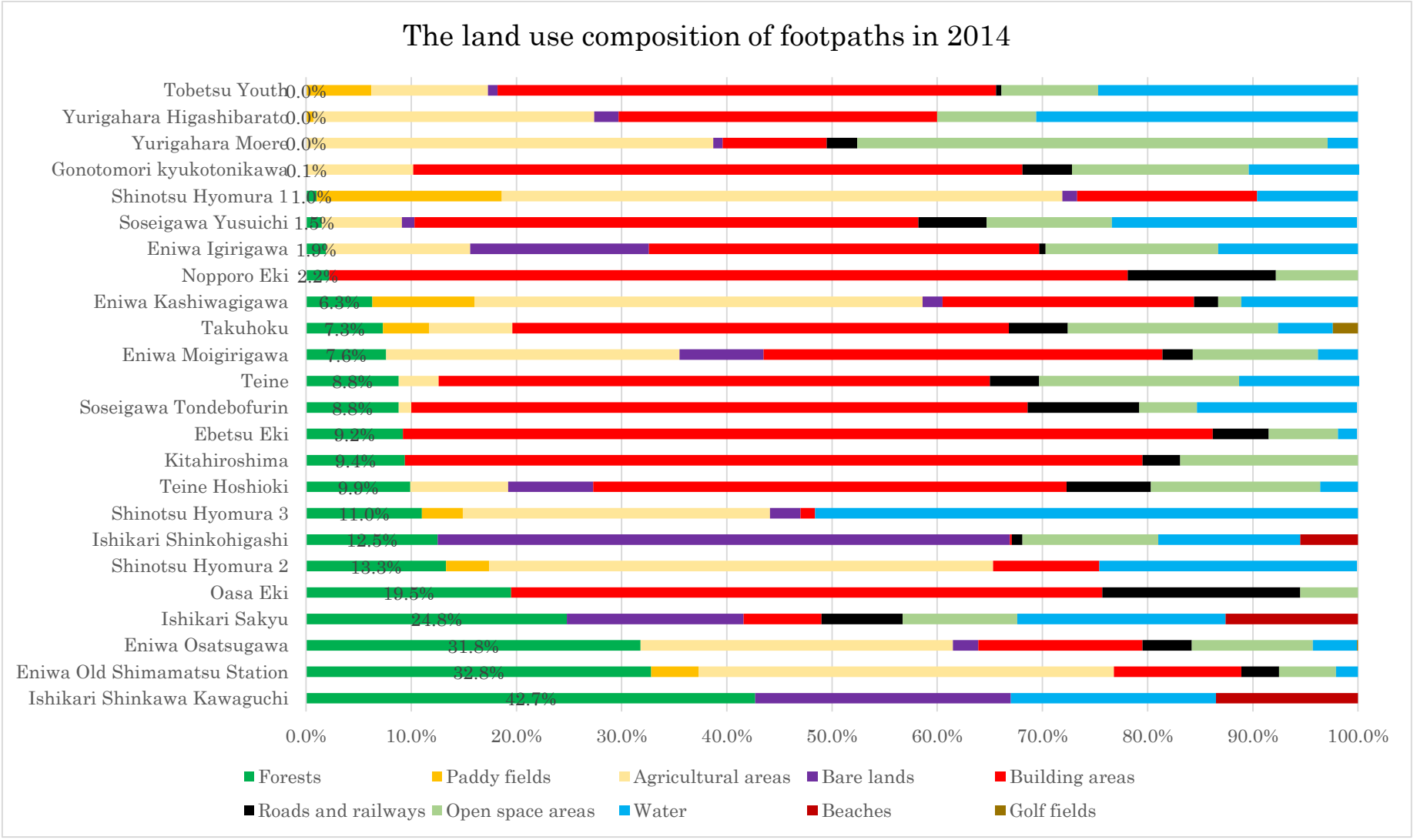


Figure 4.17 The 2014 total land use of footpaths in Ishikari Subprefecture (Forests)

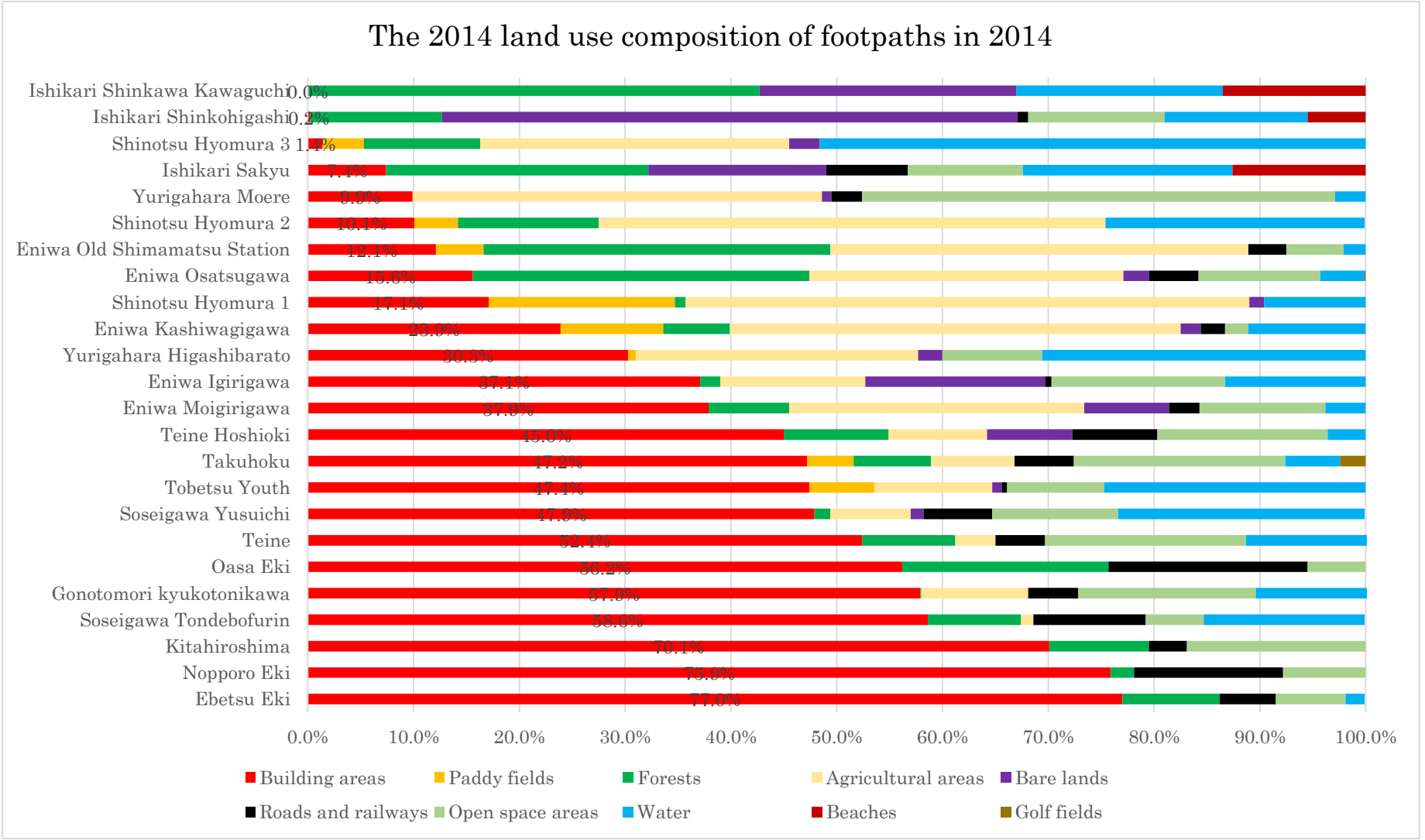


Figure 4.18 The 2014 total land use of footpaths in Ishikari Subprefecture (Building areas)

b) Type of footpath surface: Land use diversity index (Simpson's and Shannon-Wiener)

Figure 4.19 showed the Simpson's Land use Diversity Index was varied from 0.40 to 0.84 whereas the Shannon-Wiener diversity index varied from 0.77 to 1.86. Ishikari Sakyu footpath in Ishikari City has the highest Simpson and Shannon-Wiener diversity index whereas Nopporo Eki footpath has the lowest Simpson and Shannon-Wiener diversity index. This also means the Ishikari Sakyu footpath has the highest landscape diversity index and people can enjoy and experience walking in environments with different landscape.

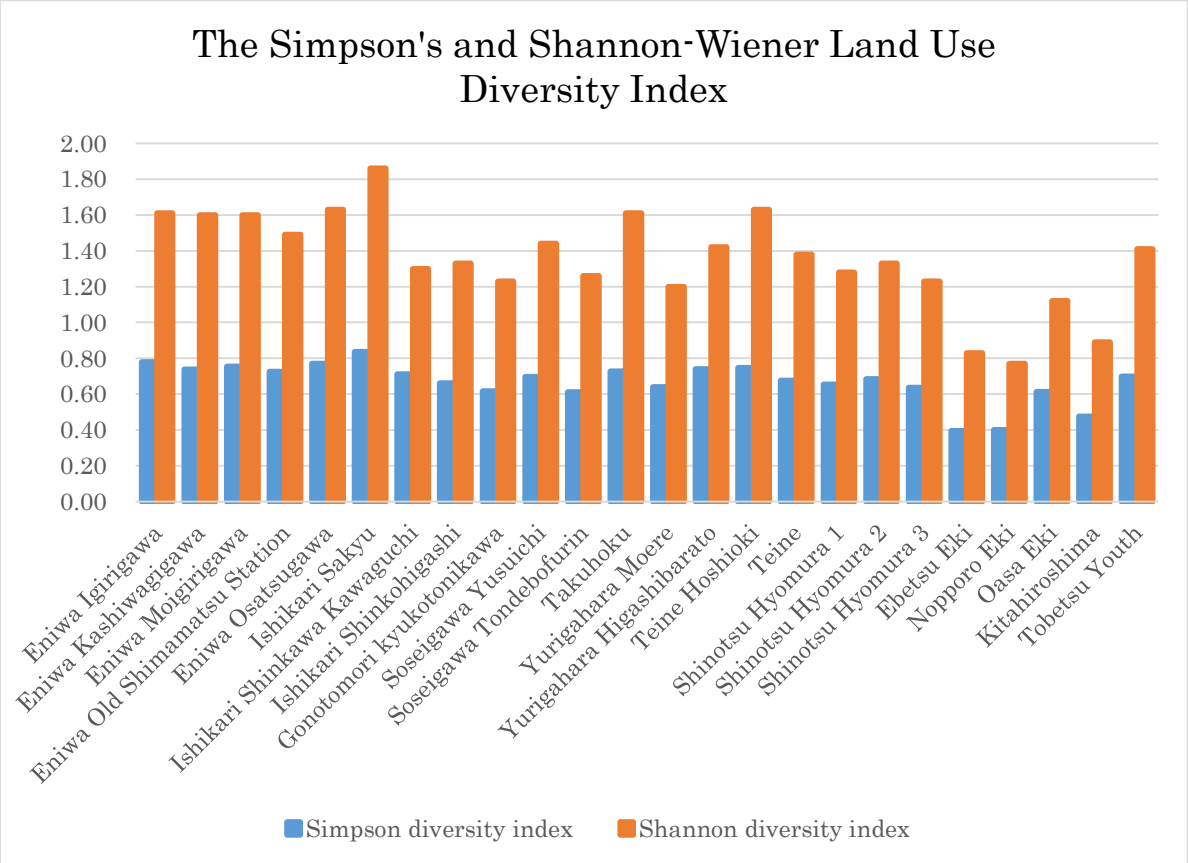
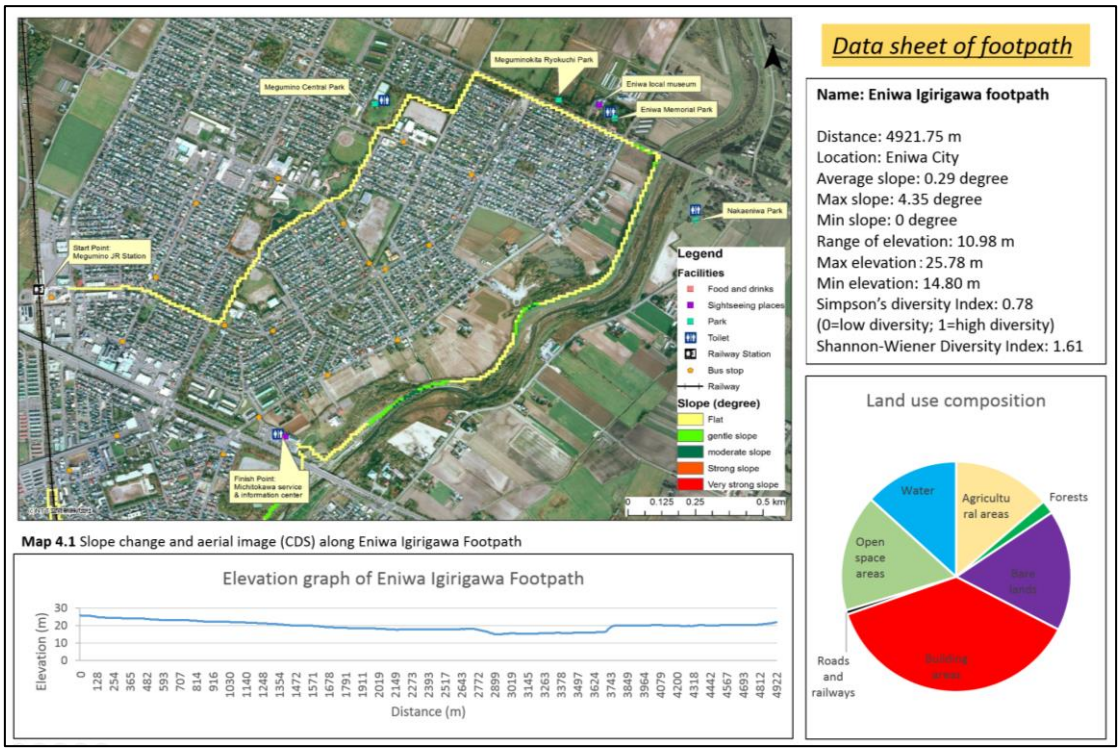


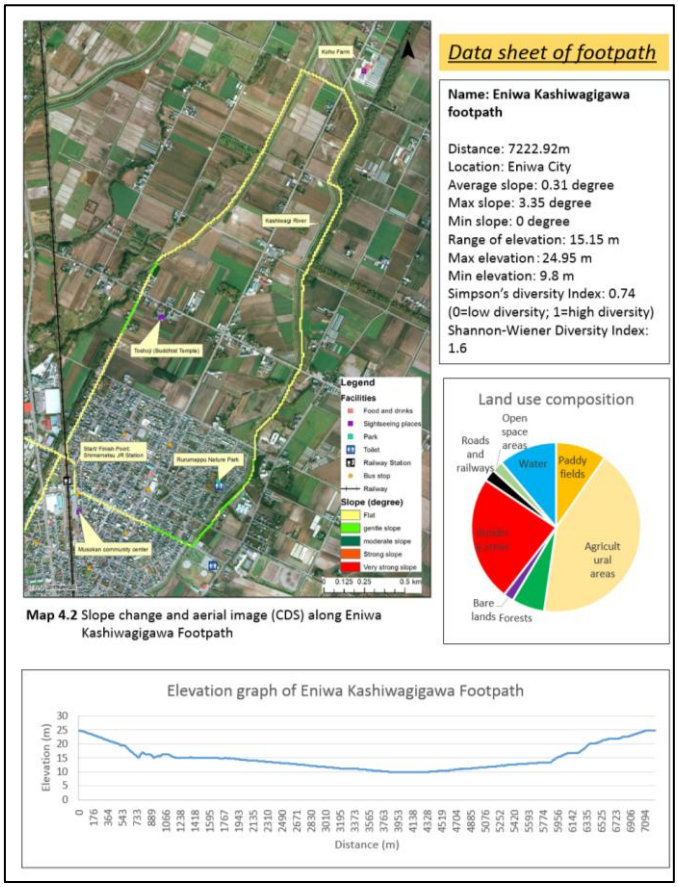
Figure 4.19 Simpson and Shannon diversity Index of footpaths in Ishikari Subprefecture

The footpaths' data sheets (Figure 4.20-4.43) were created with the combination of slope change maps, elevation graphs, land use composition pie charts and surface information of the 24 footpaths. The footpaths' data sheets allowed footpath users have a better understanding in the landscape aspects using GIS.



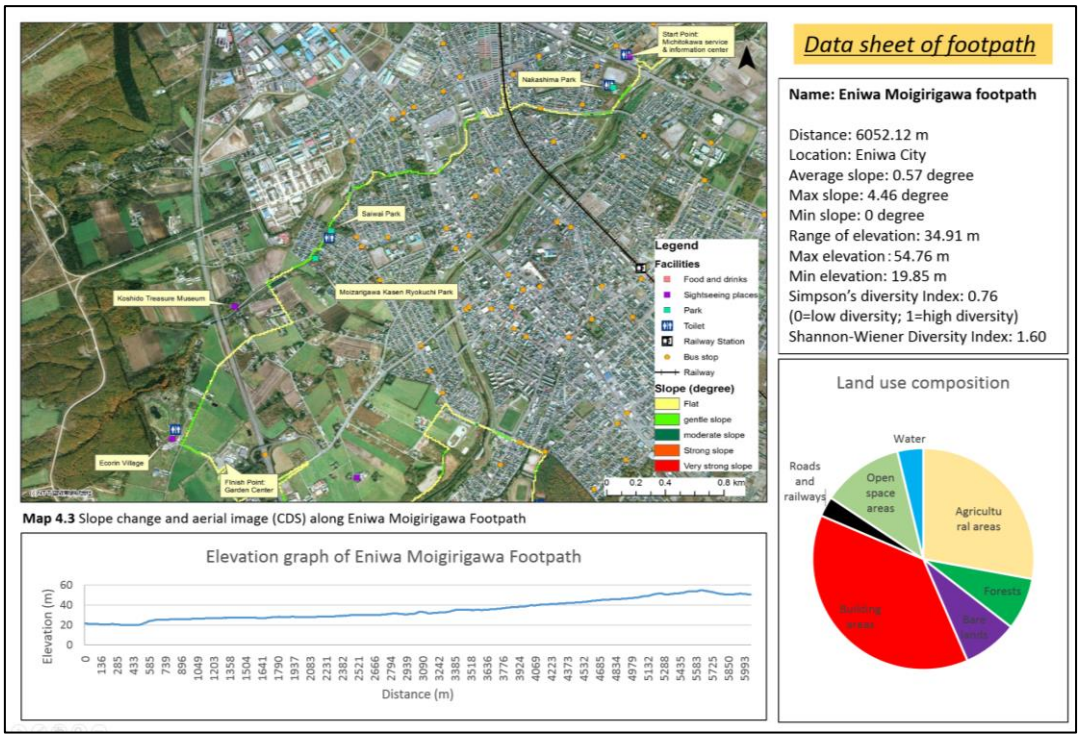
Map 4.1 Slope change and aerial image (CDS) along Eniwa Igirigawa Footpath

Figure 4.20 Eniwa Igirigawa Footpath's data sheet



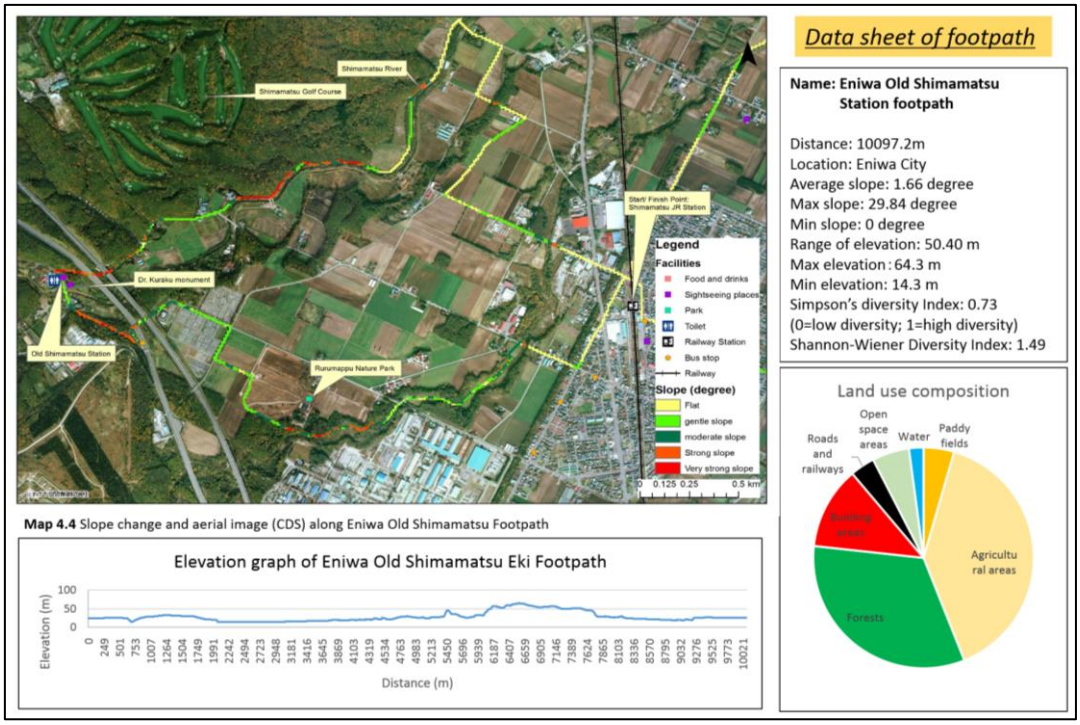
Map 4.2 Slope change and aerial image (CDS) along Eniwa Kashiwagigawa Footpath

Figure 4.21 Eniwa Kashiwagigawa Footpath's data sheet



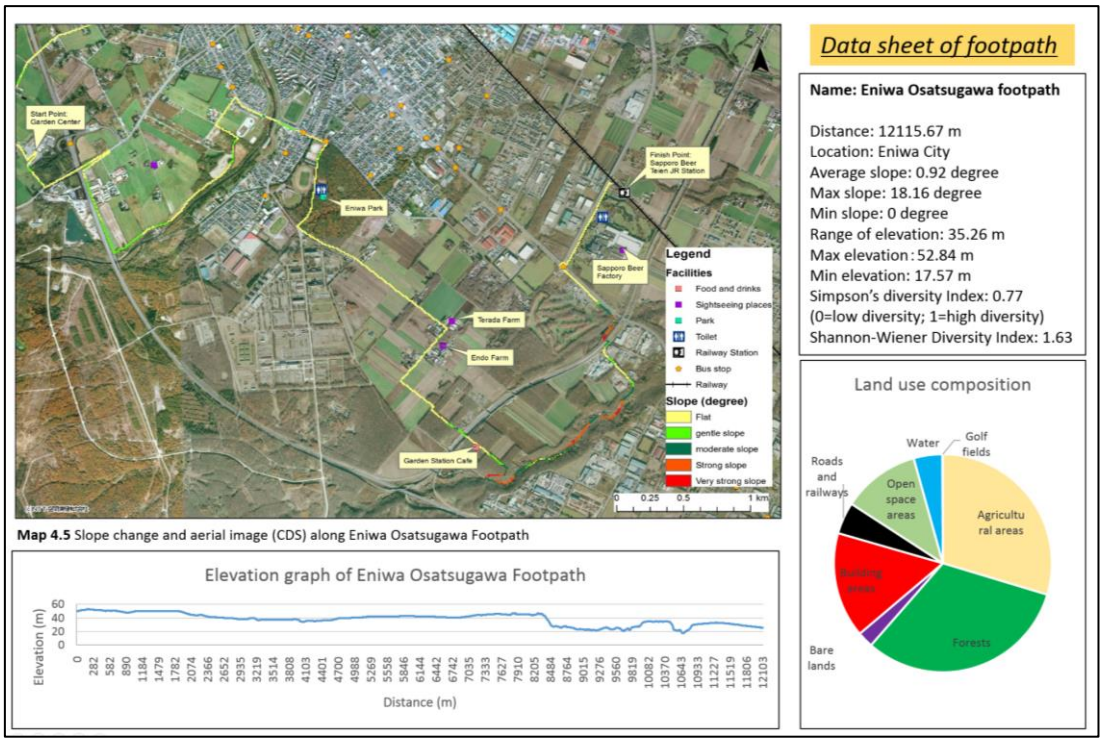
Map 4.3 Slope change and aerial image (CDS) along Eniwa Moigirigawa Footpath

Figure 4.22 Eniwa Moigirigawa Footpath's data sheet



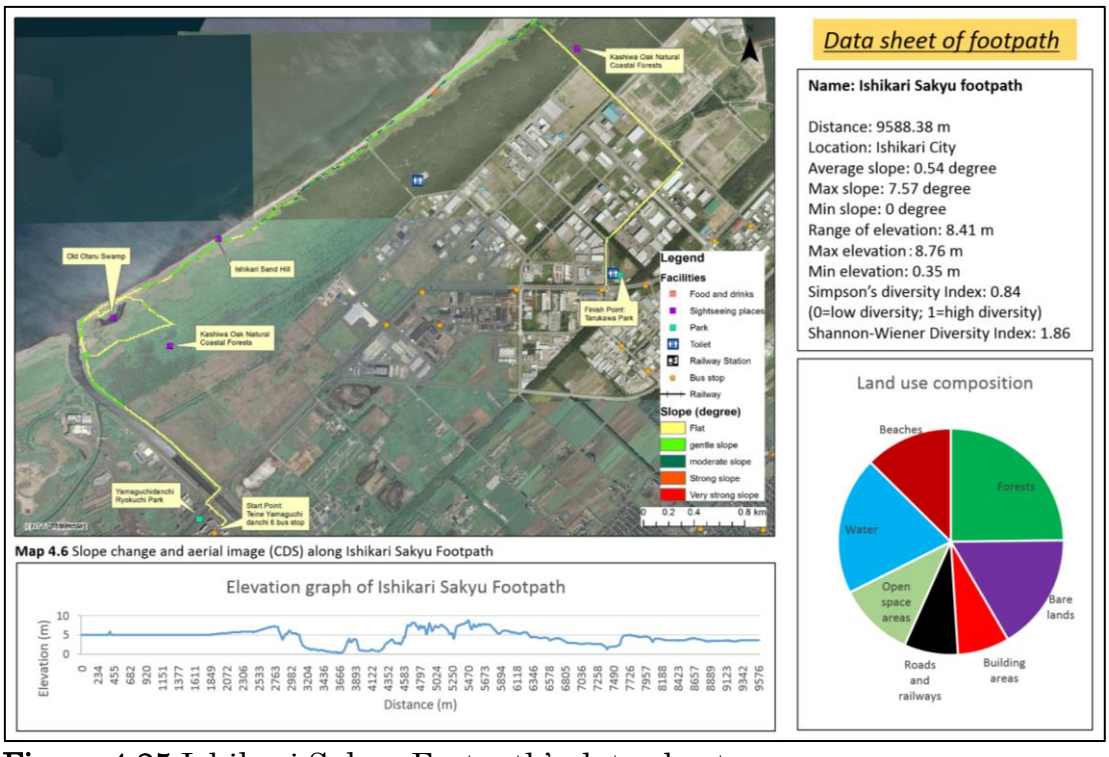
Map 4.4 Slope change and aerial image (CDS) along Eniwa Old Shimamatsu Footpath

Figure 4.23 Eniwa Old Shimamatsu Station Footpath's data sheet



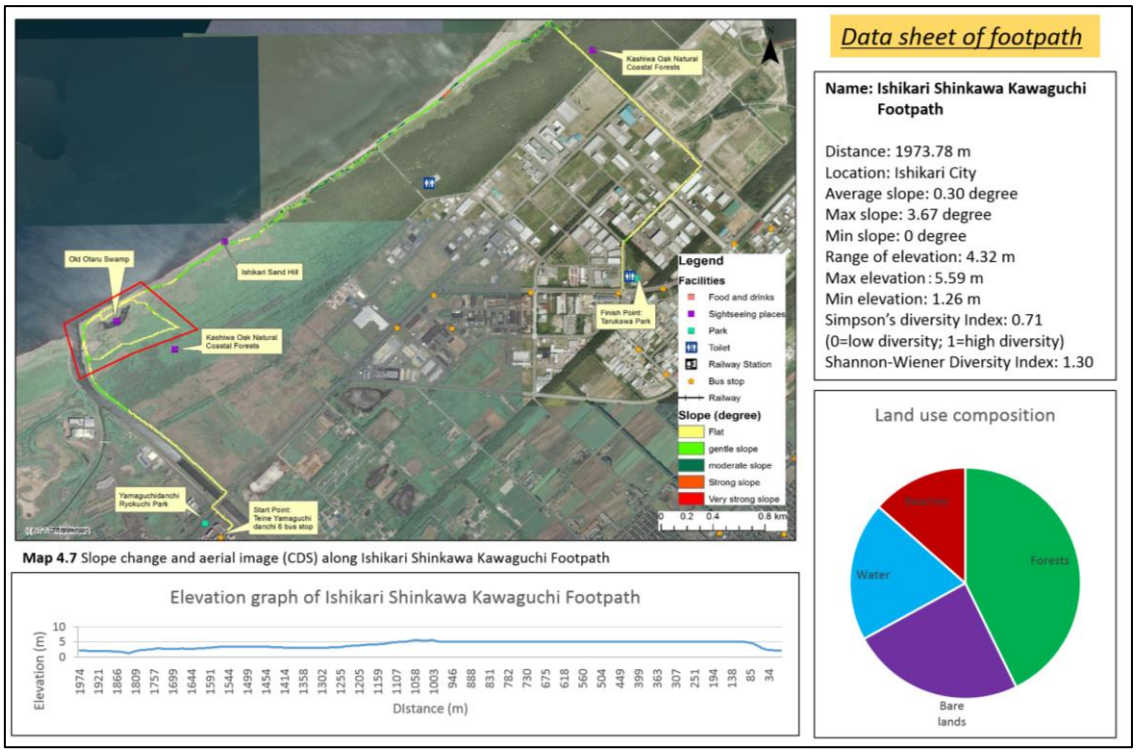
Map 4.5 Slope change and aerial image (CDS) along Eniwa Osatsugawa Footpath

Figure 4.24 Eniwa Osatsugawa Footpath's data sheet



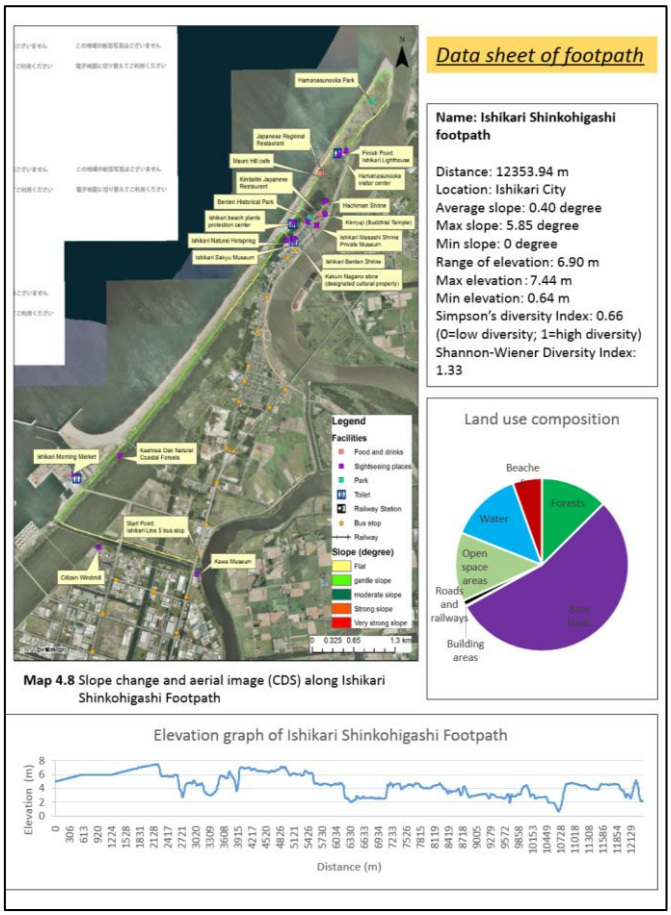
Map 4.6 Slope change and aerial image (CDS) along Ishikari Sakyu Footpath

Figure 4.25 Ishikari Sakyu Footpath's data sheet



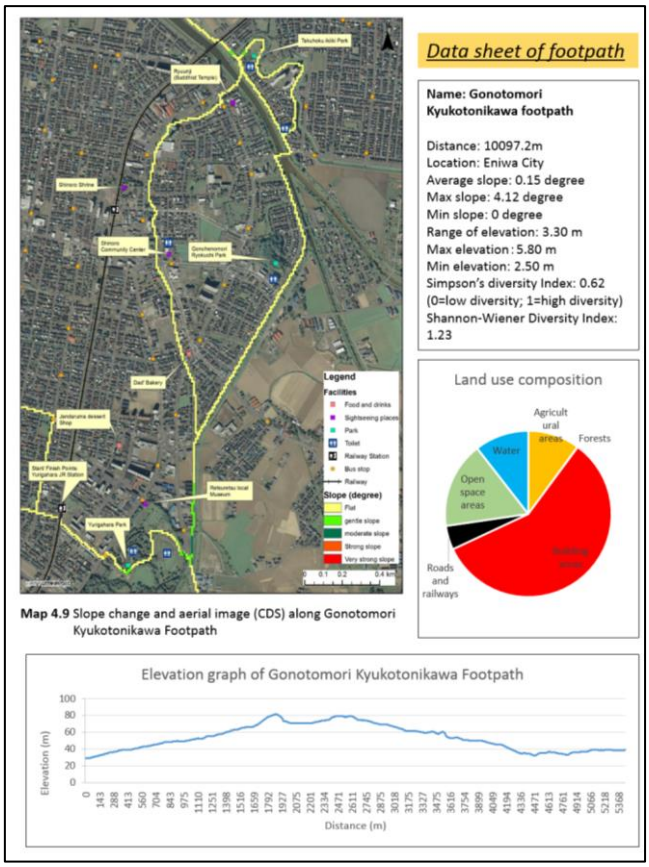
Map 4.7 Slope change and aerial image (CDS) along Ishikari Shinkawa Kawaguchi Footpath

Figure 4.26 Ishikari Shinkawa Kawaguchi Footpath's data sheet



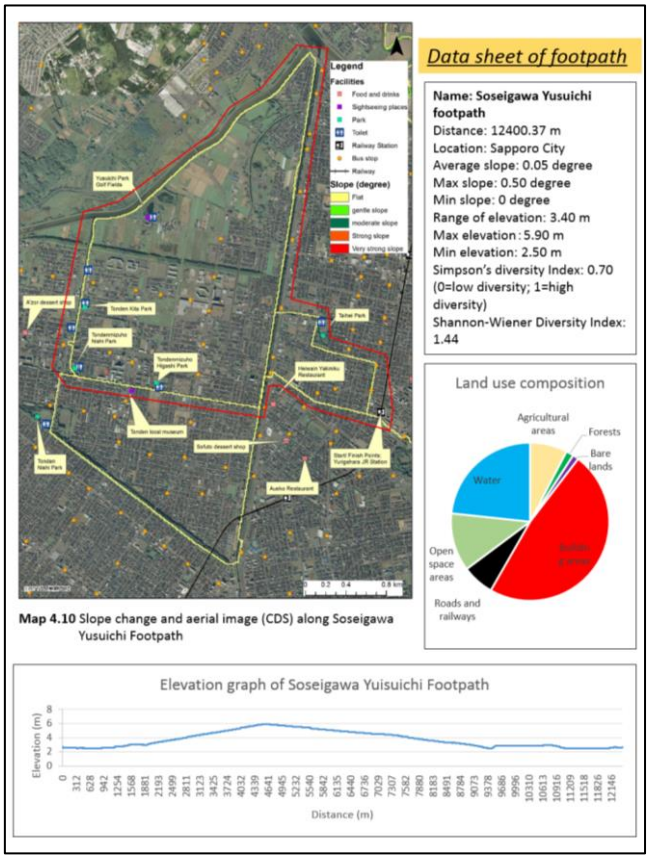
Map 4.8 Slope change and aerial image (CDS) along Ishikari Shinkohigashi Footpath

Figure 4.27 Ishikari Shinkohigashi Footpath's data sheet



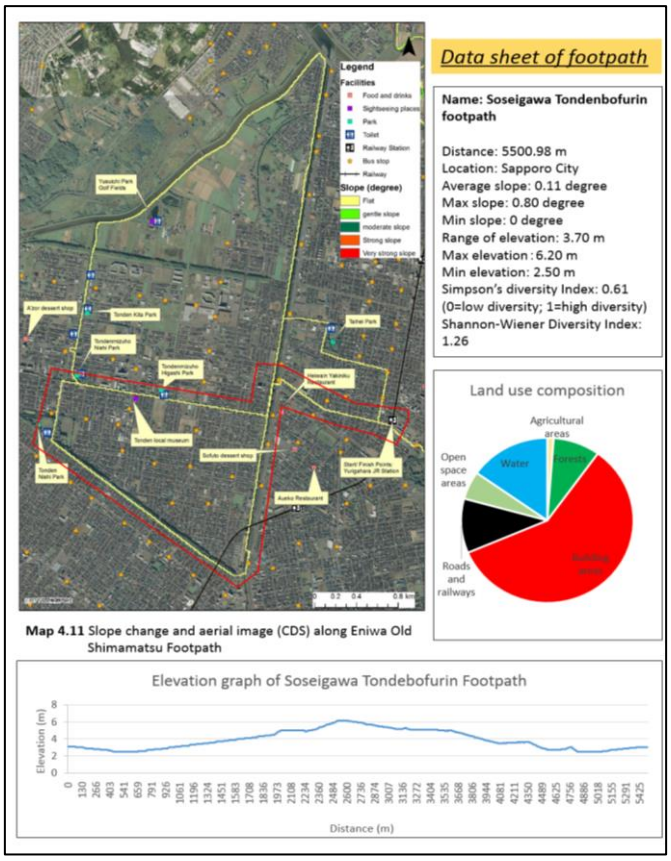
Map 4.9 Slope change and aerial image (CDS) along Gonotomori Kyukotonikawa Footpath

Figure 4.28 Gonotomori Kyukotonikawa Footpath's data sheet



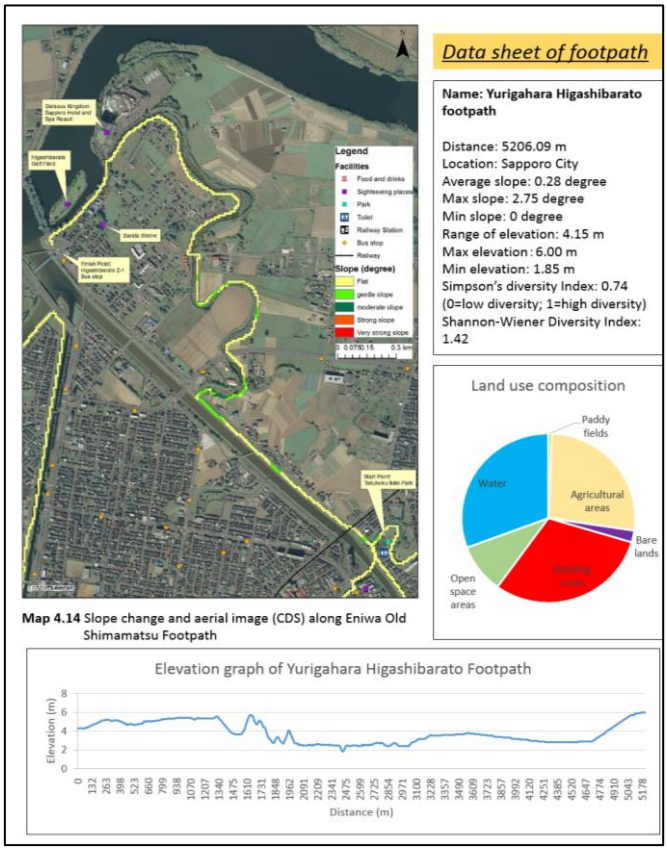
Map 4.10 Slope change and aerial image (CDS) along Soseigawa Yusuichi Footpath

Figure 4.29 Soseigawa Yuisuichi Footpath's data sheet



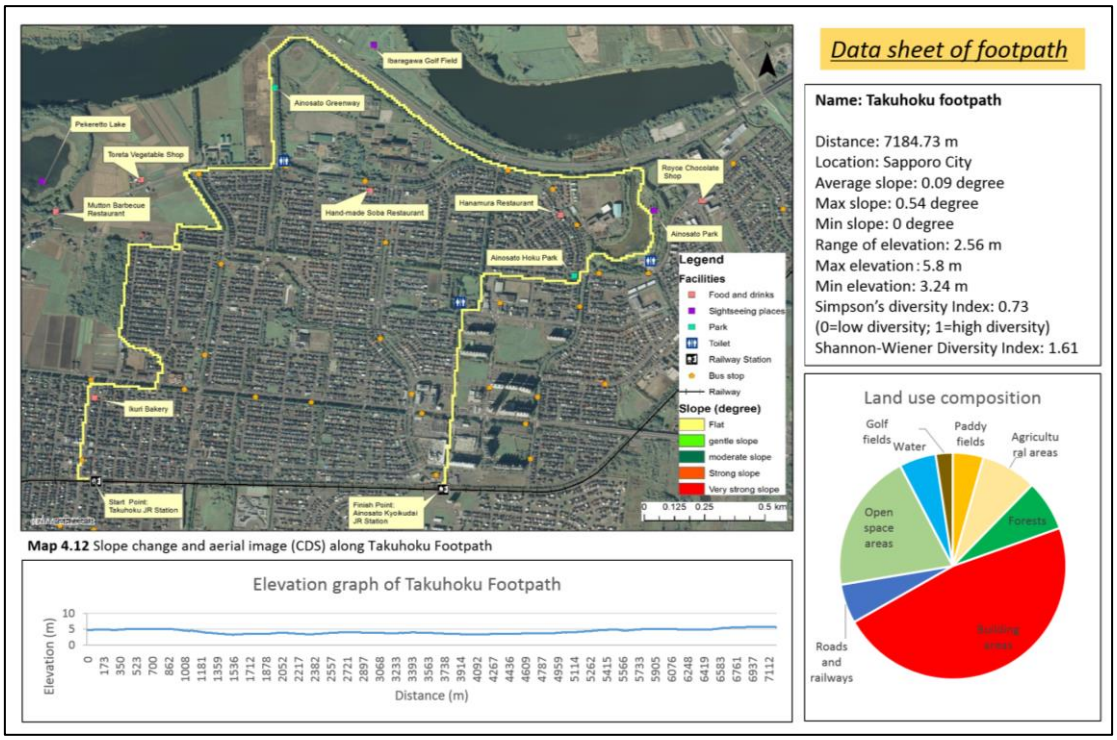
Map 4.11 Slope change and aerial image (CDS) along Eniwa Old Shimamatsu Footpath

Figure 4.30 Soseigawa Tondebofurin Footpath's data sheet



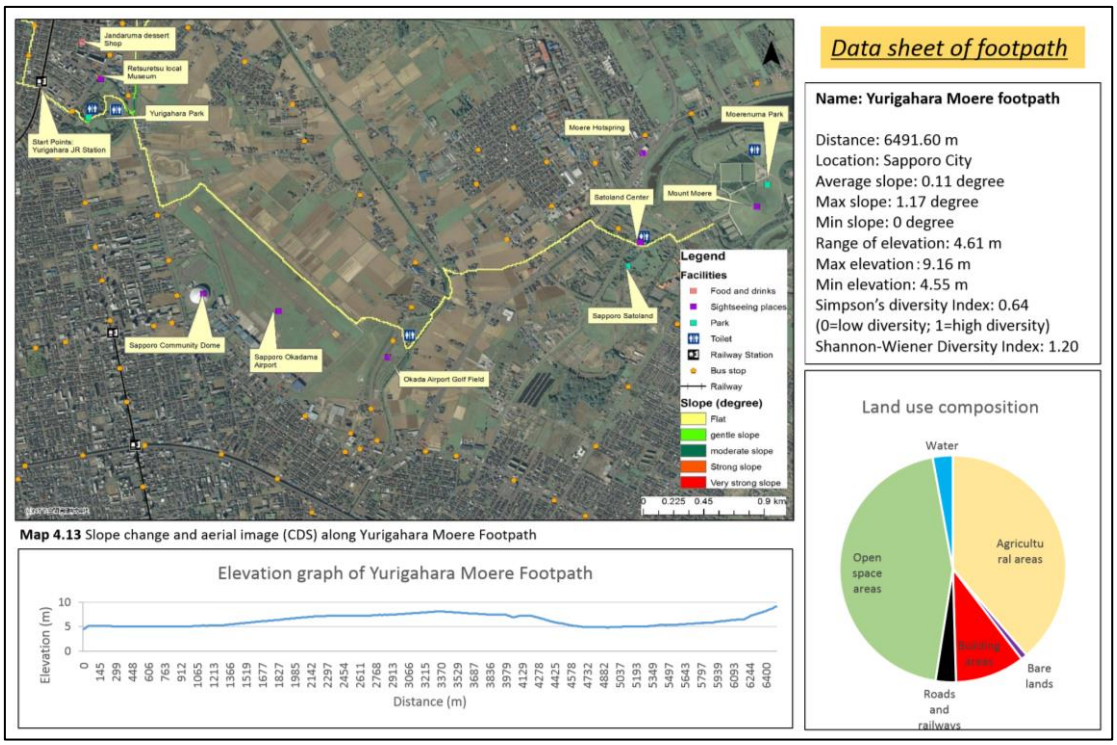
Map 4.14 Slope change and aerial image (CDS) along Eniwa Old Shimamatsu Footpath

Figure 4.31 Yurigahara Higashibarato Footpath's data sheet



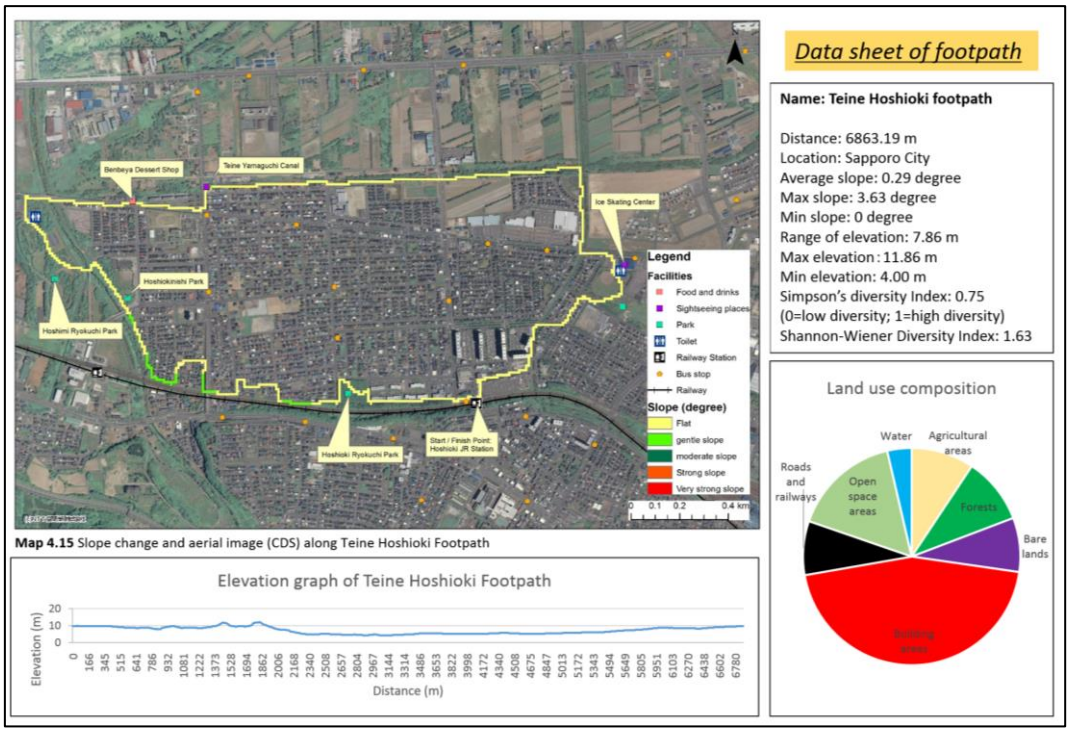
Map 4.12 Slope change and aerial image (CDS) along Takuhoku Footpath

Figure 4.32 Takuhoku Footpath's data sheet



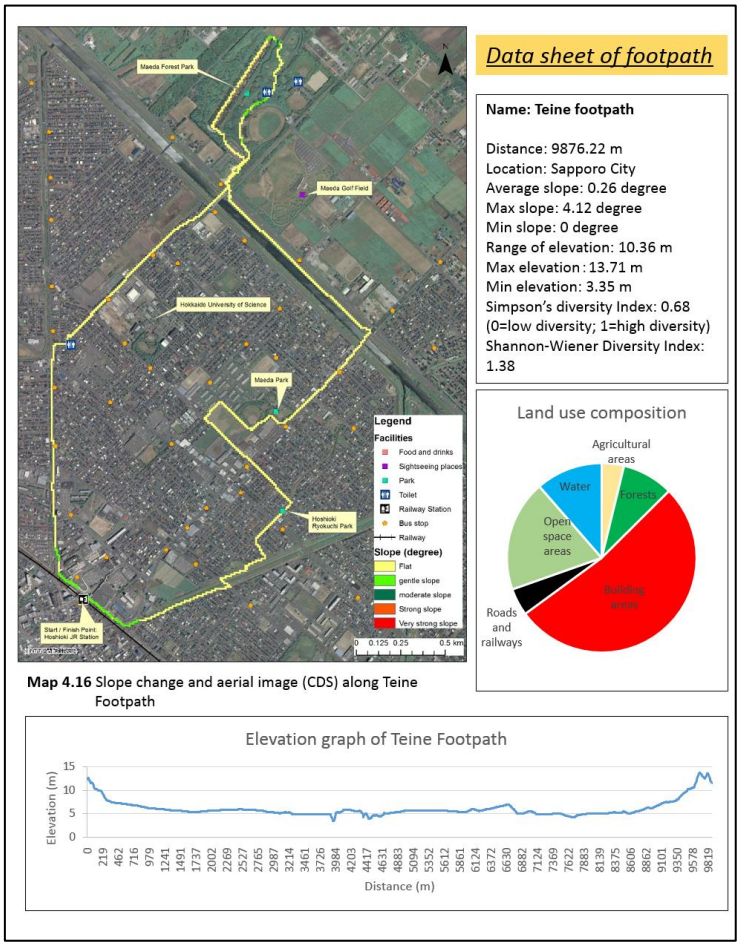
Map 4.13 Slope change and aerial image (CDS) along Yurigahara Moere Footpath

Figure 4.33 Yurigahara Moere Footpath's data sheet



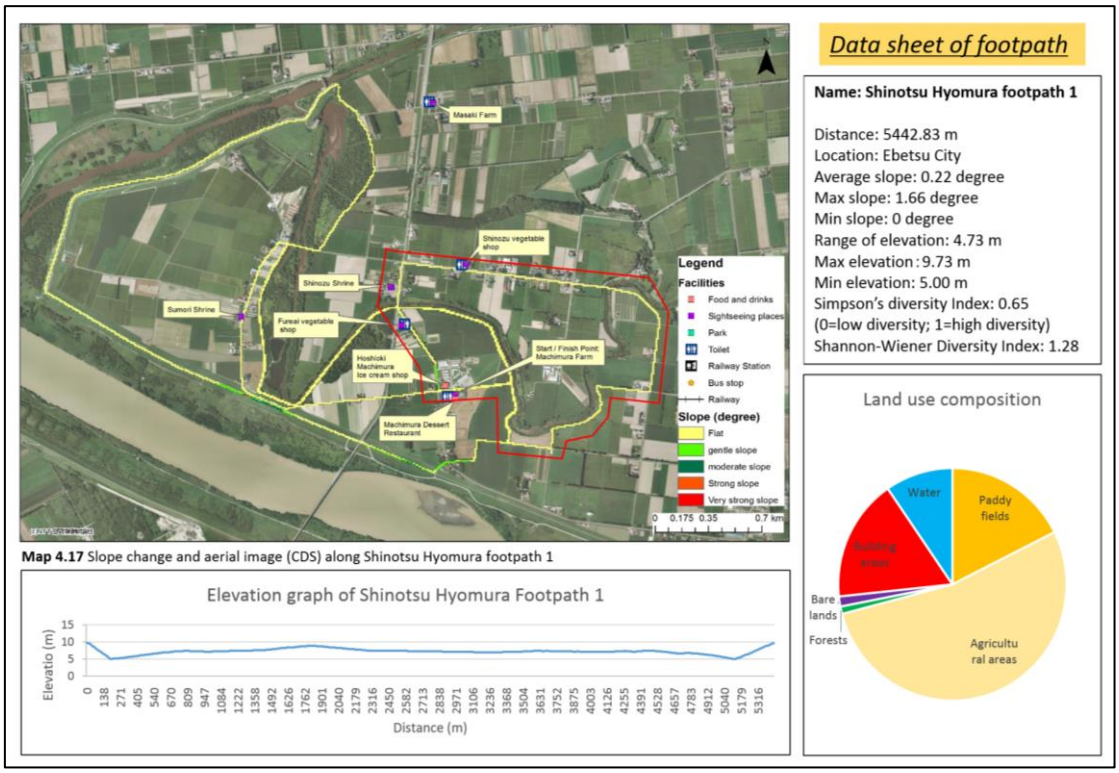
Map 4.15 Slope change and aerial image (CDS) along Teine Hoshioki Footpath

Figure 4.34 Teine Hoshioki Footpath's data sheet



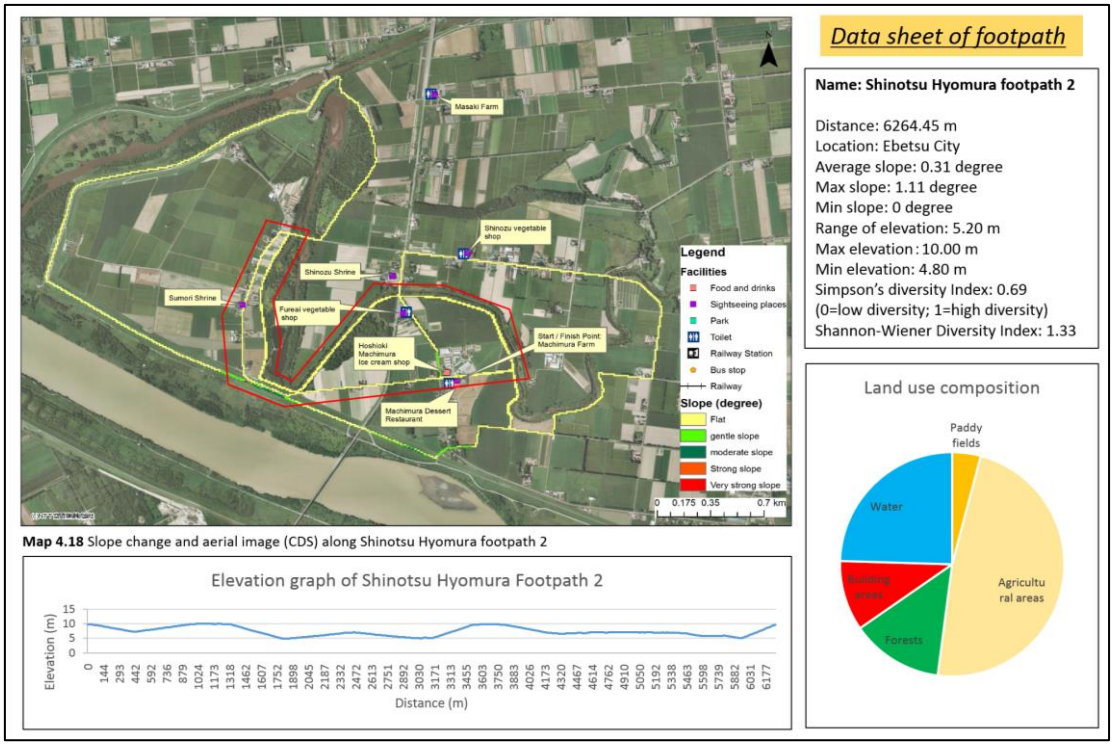
Map 4.16 Slope change and aerial image (CDS) along Teine Footpath

Figure 4.35 Teine Footpath's data sheet



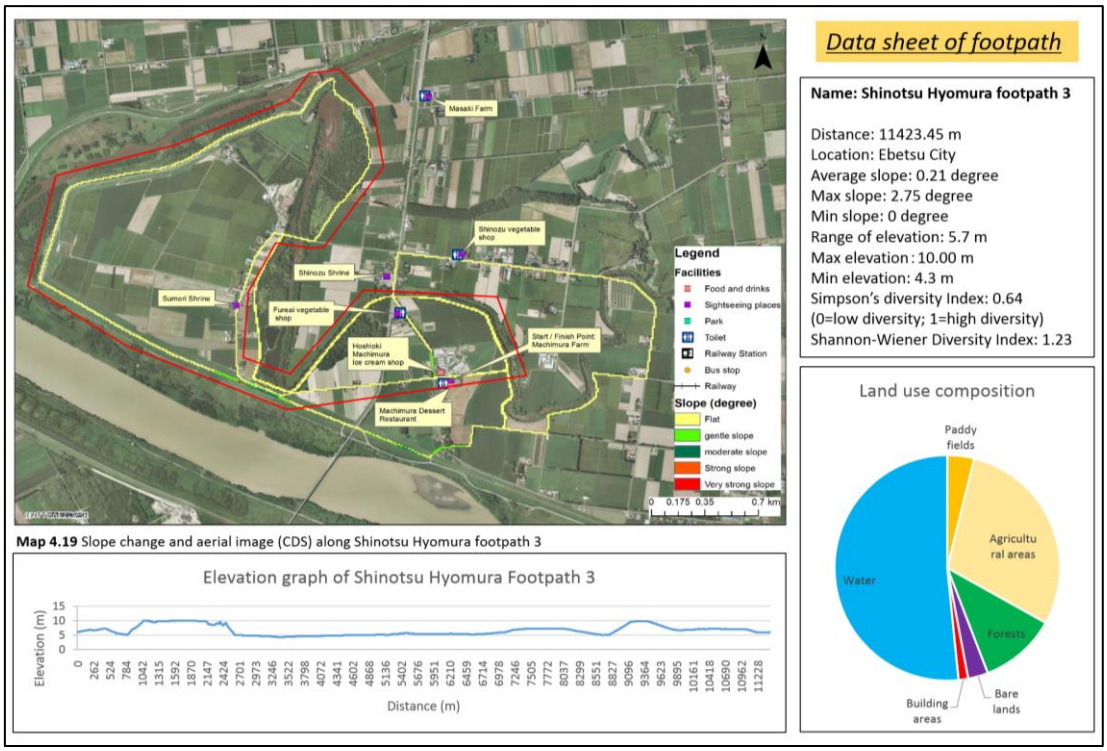
Map 4.17 Slope change and aerial image (CDS) along Shinotsu Hyomura footpath 1

Figure 4.36 Shinotsu Hyomura 1 Footpath's data sheet



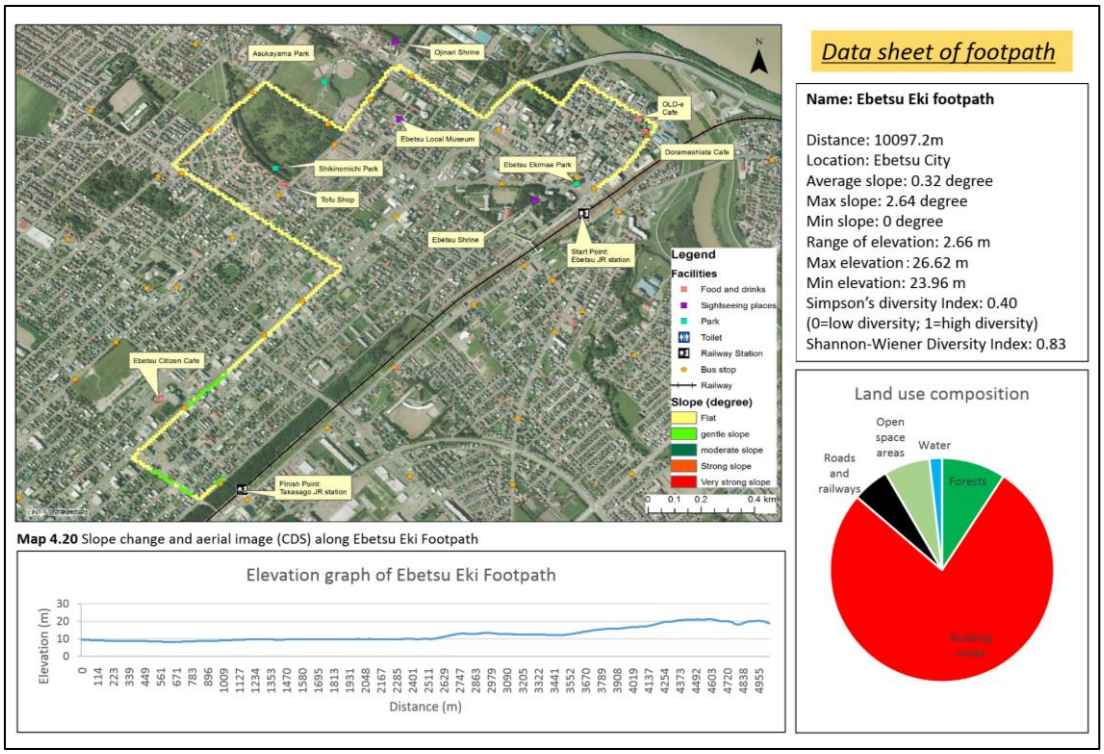
Map 4.18 Slope change and aerial image (CDS) along Shinotsu Hyomura footpath 2

Figure 4.37 Shinotsu Hyomura 2 Footpath's data sheet



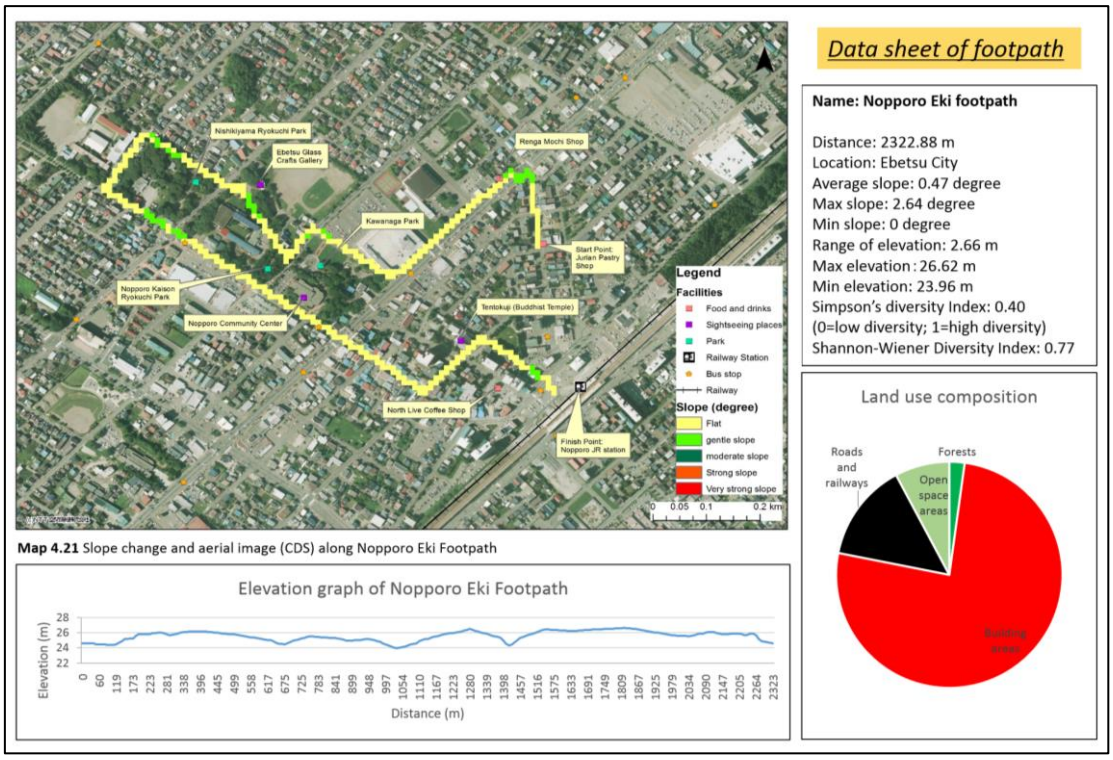
Map 4.19 Slope change and aerial image (CDS) along Shinotsu Hyomura footpath 3

Figure 4.38 Shinotsu Hyomura 3 Footpath's data sheet



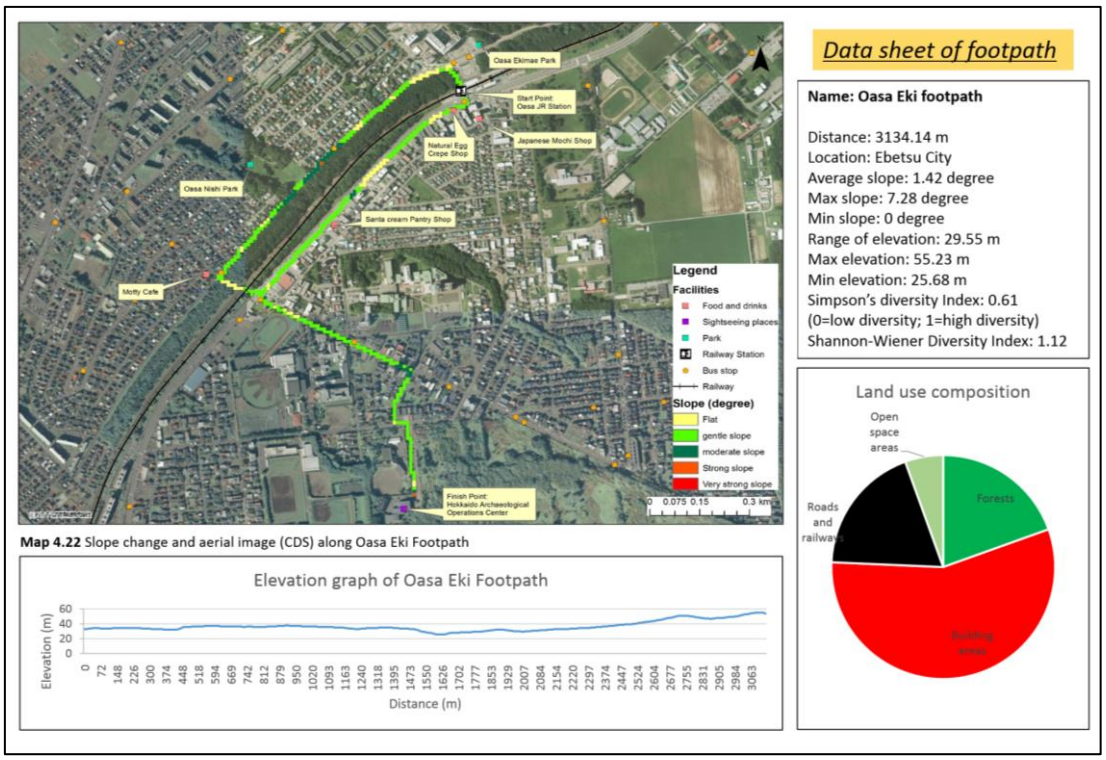
Map 4.20 Slope change and aerial image (CDS) along Ebetsu Eki Footpath

Figure 4.39 Ebetsu Eki Footpath's data sheet



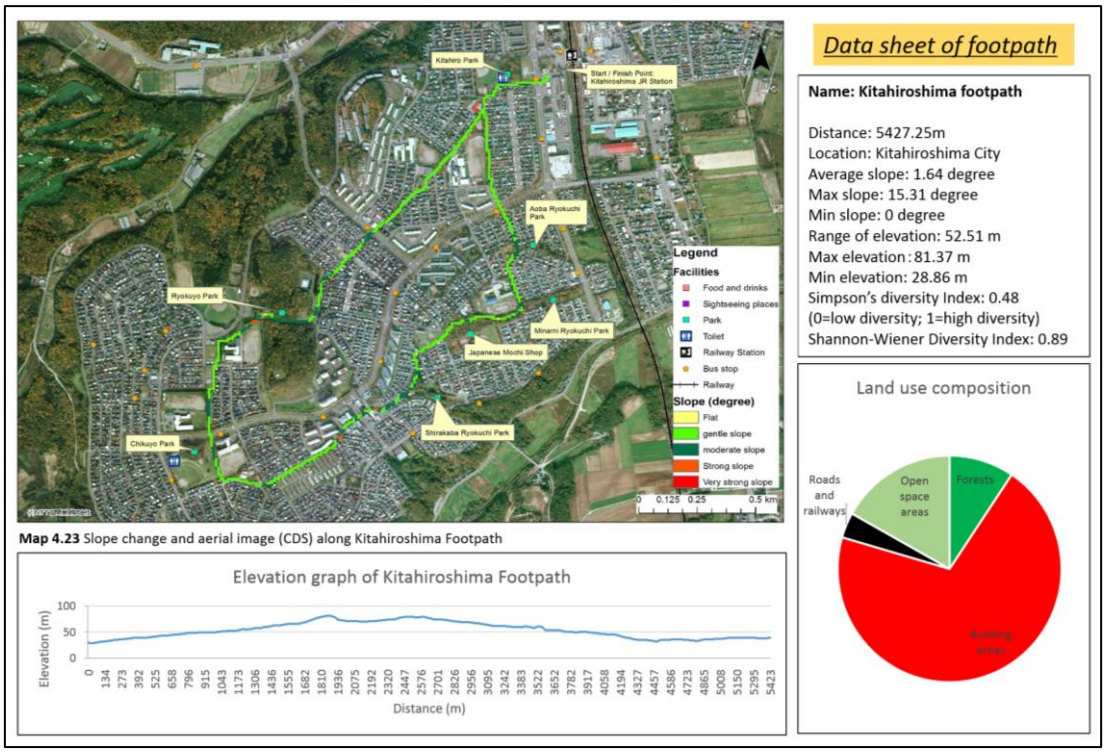
Map 4.21 Slope change and aerial image (CDS) along Nopporo Eki Footpath

Figure 4.40 Nopporo Eki Footpath's data sheet



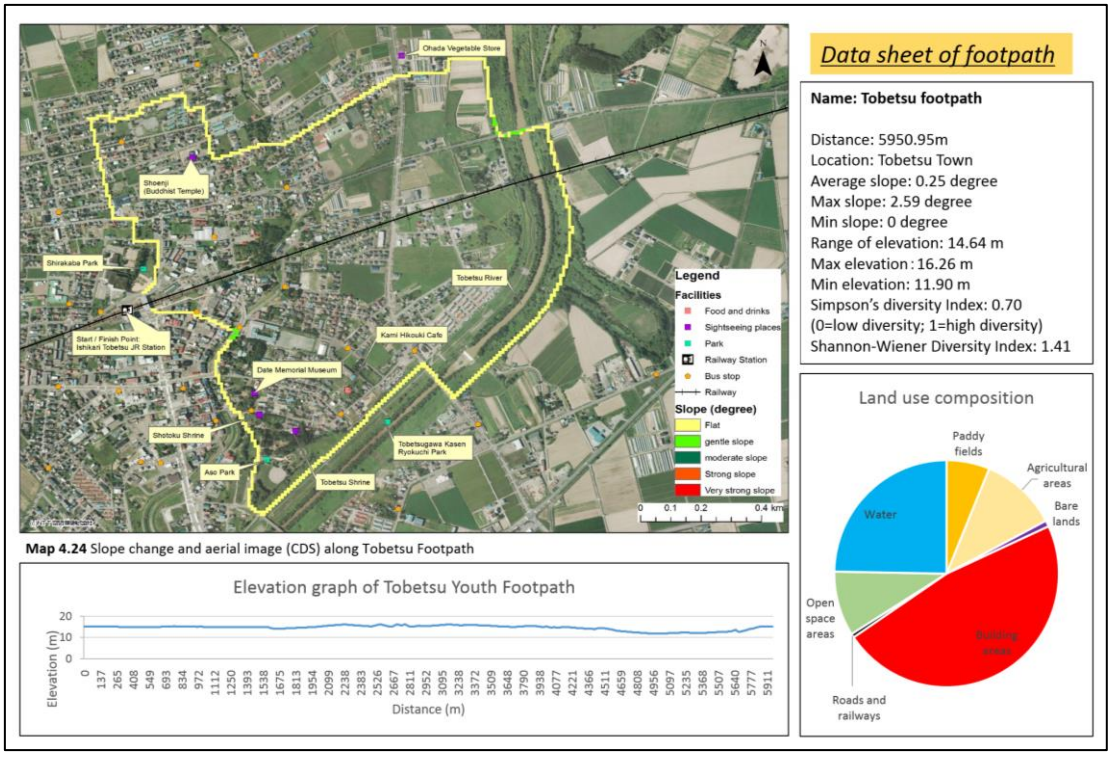
Map 4.22 Slope change and aerial image (CDS) along Oasa Eki Footpath

Figure 4.41 Oasa Eki Footpath's data sheet



Map 4.23 Slope change and aerial image (CDS) along Kitahiroshima Footpath

Figure 4.42 Kitahiroshima Footpath's data sheet



Map 4.24 Slope change and aerial image (CDS) along Tobetsu Footpath

Figure 4.43 Tobetsu Youth Footpath's data sheet

4.2.3 Existing footpath maps

a) Type of footpaths

For the statement of "type of footpaths (footpath system)" in this study, 13 (54.17%) of the footpaths are loop type footpaths, whereas, 11 (45.83%) of the footpaths are linear type footpaths (Figure 4.44). From the result, the number of loop type footpaths in the Ishikari Subprefecture maybe not so enough because 82.5% of the respondents in this questionnaire survey preferred loop type footpaths.

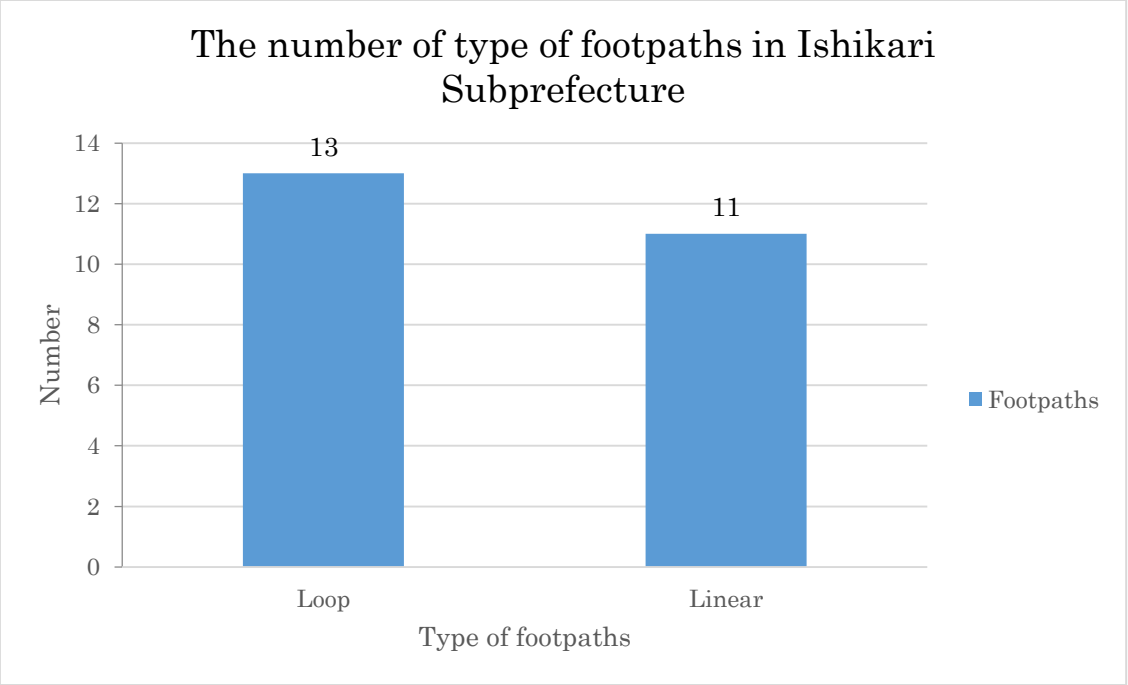


Figure 4.44 The number of footpaths in Ishikari Subprefecture by type of footpaths (n=24)

b) Place for the start/ finish points of footpaths

For the statement "location of the start and finish points of the footpaths" in this study, most of them are located in the train or bus stations. There were (70.83%) 17 of start points and (62.5%) 15 of finish points of footpaths located in a train station or bus stops. Footpaths starting and finish points located at the parks or gardens are the least which is one in start point and two in finish points only. (Figure 4.45). 85.3% of the respondents in this questionnaire survey preferred train or bus stations as start and finish points of footpaths. Therefore, current place for the start and finish points of footpaths in Ishikari Subprefecture fulfill the preference of respondents in this questionnaire survey.

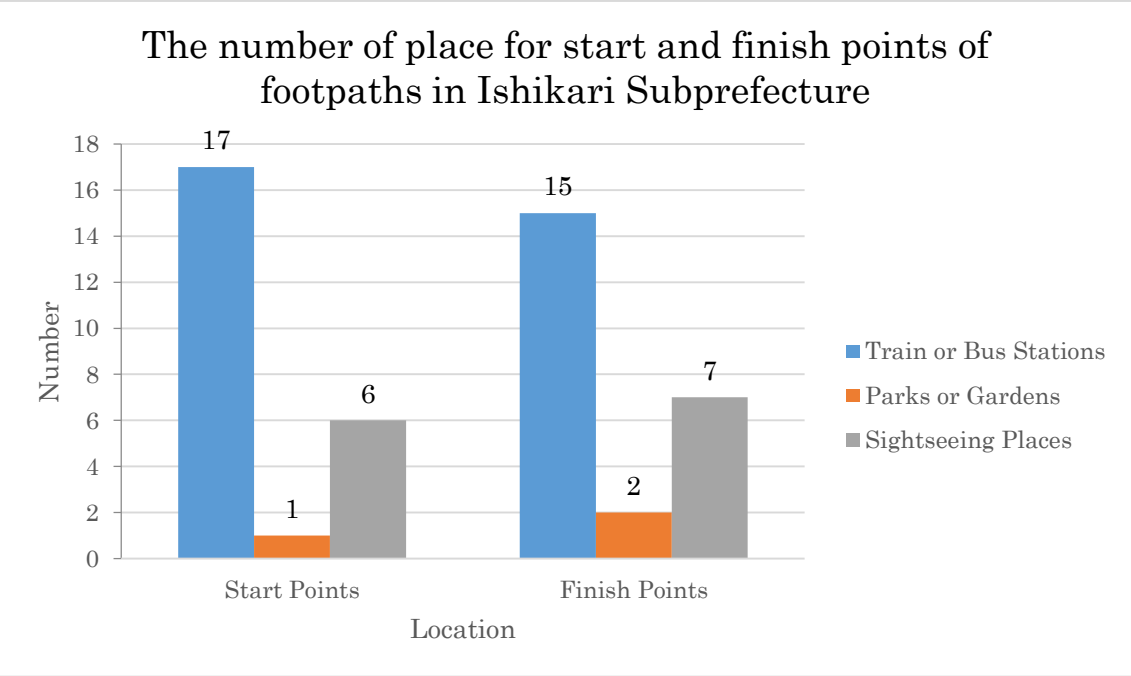


Figure 4.45 The percentage of location of start and finish points of footpaths in Ishikari Subprefecture (n = 24)

c) Regional resources and facilities

According to the result of the statement “Which geographical information to be important included in the footpath map”, the location of bus stops, train stations, sightseeing places, toilets and rest places are the important geographical information to be included in the footpath map.

Table 4.12 showed the evaluation of the characteristics of footpath maps based on whether regional resources and facilities are mapped in existing footpath maps. 16 out of the 24 footpaths have regional resources and facilities that are completely mapped in existing footpath maps. For public transportation, there are 21 footpaths can be accessed by using the buses and trains based on the public transportation points mapped in the existing footpath maps. There are only three footpaths which are Shinotsu Hyomura footpath 1, 2 and 3 cannot access by public transportation and only can be accessed by cars.

For sightseeing places such as shrines, museums, local vegetable shops, historical buildings, art centers and others, there are 23 footpaths have sightseeing places based on sightseeing places points mapped in the existing footpath maps. Whereas, the Kitahiroshima footpath didn't have any sightseeing places points in the existing footpath maps.

For toilets, there are 19 footpaths have toilets based on toilets points mapped in the existing footpath maps. The toilets refer to the available of toilets along the footpaths except the toilets in a train station. There are five footpaths in this study which is Ishikari Shinkawa Kawaguchi, Nopporo Eki, Oasa Eki, Ebetsu Eki and Tobetsu Youth footpaths don't have toilets points in the existing footpath maps.

For rest places, there are 20 footpaths have rest places based on rest places points mapped in the existing footpath maps. The rest places refer to the availability of benches, parks, visitor center or community center along the footpaths. There are only four footpaths in this study which is Ishikari Shinkawa Kawaguchi, Shinotsu Hyomura 1, 2 and 3 footpaths don't have the rest places points in the existing footpath maps.

Table 4.12 Evaluation of the characteristics of footpath maps based on whether regional resources and facilities are mapped in existing footpath maps

Categories	Type of footpaths	Name of footpath	Regional resources and facilities			
			Public transportation	Sightseeing places	Toilets	Rest places
Less than 5km	Loop	Ishikari Shinkawa Kawaguchi	Bus	Yes	No	No
	Linear	Eniwa Igirigawa	Train and bus	Yes	Yes	Yes
		Nopporo Eki	Train	Yes	No	Yes
		Oasa Eki	Train	Yes	No	Yes
5-7km	Loop	Gonotomori kyukotonikawa	Train	Yes	Yes	Yes
		Soseigawa Tondebofurin	Train	Yes	Yes	Yes
		Teine Hosioki	Train	Yes	Yes	Yes
		Shinotsu Hyomura 1	Car	Yes	Yes	No
		Shinotsu Hyomura 2	Car	Yes	Yes	No
		Kitahiroshima	Train	No	Yes	Yes
		Tobetsu Youth	Train	Yes	No	Yes
	Linear	Eniwa Moigirigawa	Bus	Yes	Yes	Yes
		Yurigahara Moere	Train and bus	Yes	Yes	Yes

		Yurigahara Higashibarato	Train and bus	Yes	Yes	Yes
		Ebetsu Eki	Train	Yes	No	Yes
7-10km	Loop	Eniwa Kashiwagigawa	Train	Yes	Yes	Yes
		Teine	Train	Yes	Yes	Yes
	Linear	Ishikari Sakyu	Bus	Yes	Yes	Yes
		Takuhoku	Train	Yes	Yes	Yes
more than 10km	Loop	Eniwa Old Shimamatsu Station	Train	Yes	Yes	Yes
		Soseigawa Yusuichi	Train	Yes	Yes	Yes
		Shinotsu Hyomura 3	Car	Yes	Yes	No
	Linear	Eniwa Osatsugawa	Bus and train	Yes	Yes	Yes
		Ishikari Shinkohigashi	Bus	Yes	Yes	Yes

4.3 New footpath route planning for young adults around Oasa Station, Ebetsu using ArcGIS Network Analyst

The main factor for footpath route planning considered in this study is the length of footpaths because different age groups of respondents preferred different length of footpaths. According to the result of questionnaire surveys, young adult group preferred 3-5 km, middle aged group preferred 5-7 km and older adult group preferred 7-10 km length of footpaths respectively. Then, the second factor is scenic appeal. Footpaths with interesting sightseeing places and scenic nature views such as forest areas can attract more people using it. Lastly, the factors are the type of footpaths, availability of public transportation and facilities such as toilets and rest places (parks) along the footpaths.

Different age groups in this study showed they have the same perspective in the preferable characteristics of footpaths and footpath maps. Both of them preferred footpaths with loop type, start and finish point in train stations or bus stops, walk through the sightseeing places and forest areas (nature, scenic views) as well as available of public facilities such as toilets and rest places along the footpaths. Since the young adults preferred short distance of footpaths, the ArcGIS Network Analyst tool can be useful to create the shortest footpath routes that can walk through the sightseeing places in the optimal order.

The road network dataset is used to run network analysis for searching the shortest route from one point to another point. Figure 4.46 showed the footpath route stops selection using network analyst in this study, stop 1 is starting point, stop 2 and 3 is sightseeing places and stop 4 is the finish point. Then, the optimal route with an impedance of length (meters) was set before running the network analysis. The output of the network analysis, a new footpath route was planned, created and proposed for the young adults around the Oasa JR station. The new footpath was planned and created according to the characteristics and criteria preferred by the young adult group in this study. As shown on Figure 4.47, the footpath map showed that the new footpath route passing through the forest areas, agriculture areas, building areas, toilets and parks (resting places). Therefore, people can enjoy different scenic natural views and use the public facilities when they are walking along the proposed footpaths. Meanwhile, the existing Oasa Eki footpath mostly located in building areas and no toilets available along the footpath.

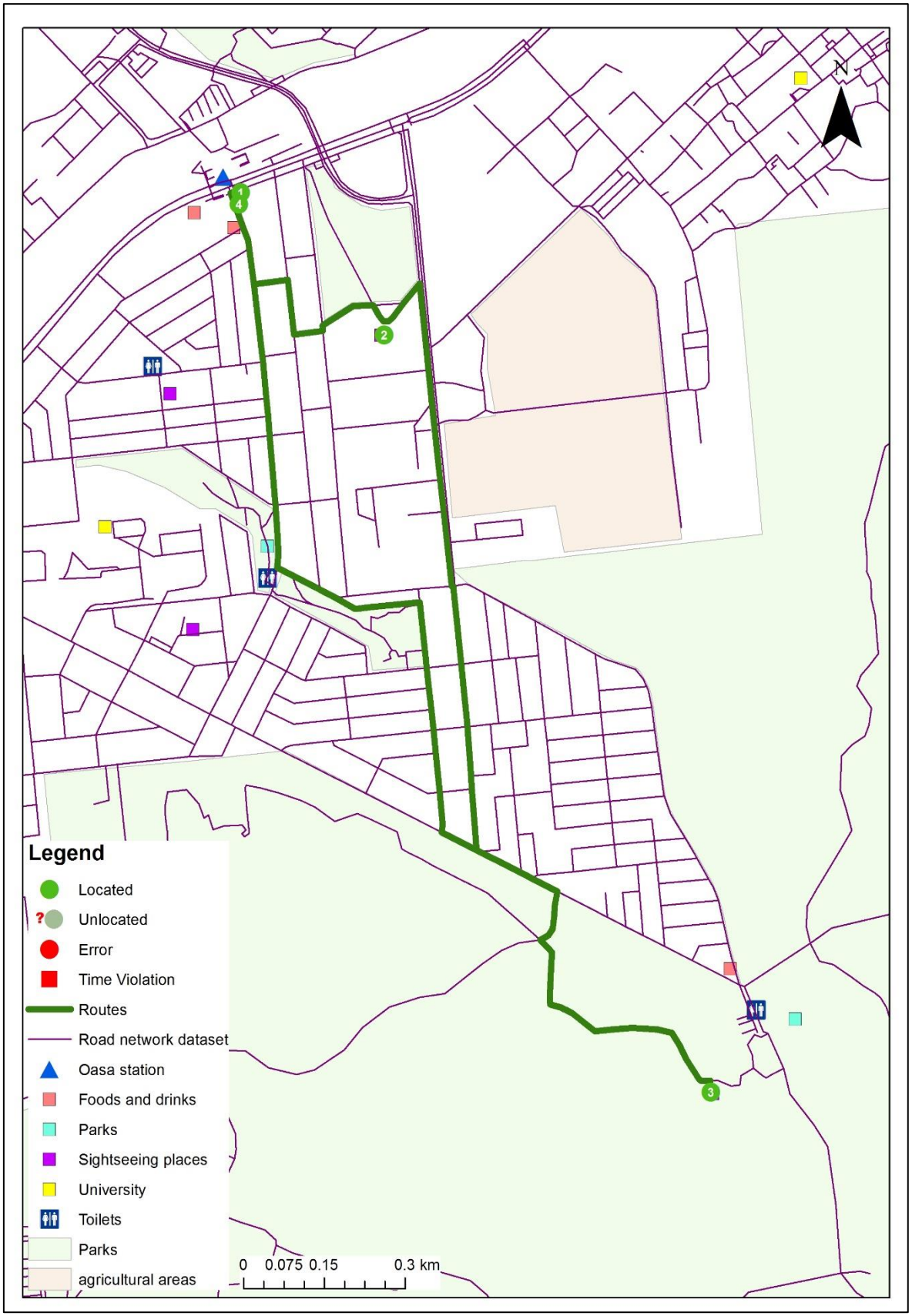


Figure 4.46 The optimal route (green color) with starting stop 1 and terminal stop 4 was created by ArcGIS network analyst

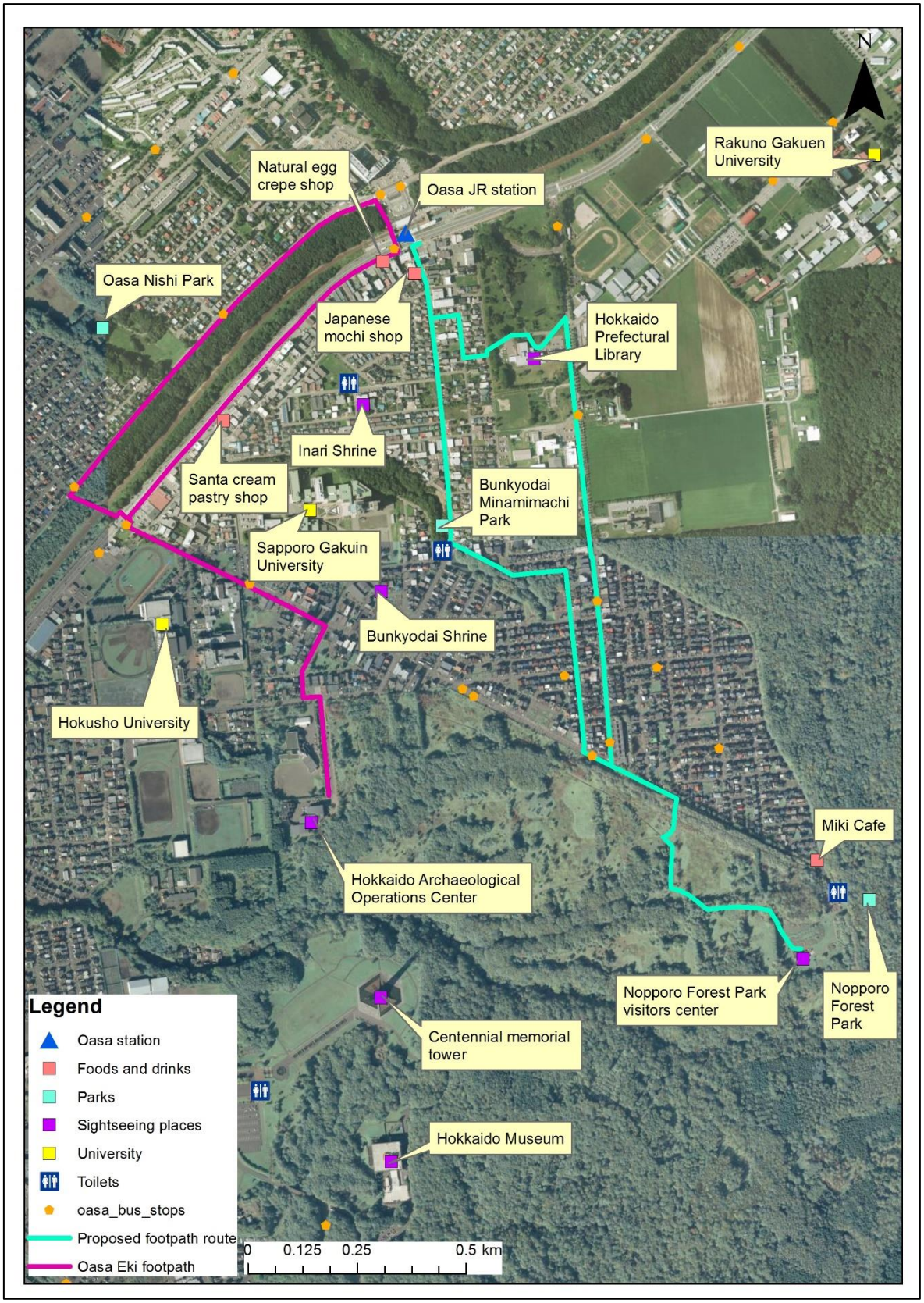


Figure 4.47 Footpath map of the existing Oasa Eki footpath (3.1km) and new planned footpath route (4.7km) by ArcGIS Network analyst with Geospace CDS as background map

CHAPTER 5 DISCUSSION

5.1 Preferable characteristics of footpaths and footpath maps by the different age groups by questionnaire survey

Walking is the most common physical activity for general population as well as older people, overweight people and people with low income. This is because walking is the exercise that considers easy, no need skill or special equipment, low cost and low impact exercise to the entire body. The footpaths that built in a particular community are believed able to encourage more people in walking and bring positive consequences (Housemann & Saint Louis, n.d.).

Footpath can encourage people at greatest risk of physical inactivity involve themselves in physical activity. Available of walking trail showed a doubling of the rate of walking trail use was found in the study done by Brownson *et al.* (2004). Physical activity including walking has significant benefits to health since it can reduce rates of chronic disease. Footpaths have many benefits to individual users and local communities. For individual users, it can let people feel good in physically, mentally and emotionally. For local communities, it can result in a high local economic benefit because footpath users spent money during their visit to the footpaths.

5.1.1 Preferable characteristics of footpaths by the different age groups

In this study, the number of older adults has the highest number because footpath walking is kind of exercise that easy going and popular for old people. This is because an older adult group can only involve in physical activity that lowers than average level (Ramblers & Macmillan Cancer Support, n.d.). Respondents also prefer walking with friends and family because walking in groups can inspire each other to walk or exercise more. Besides, it also can let people meet more new friends and it makes people feel good and stay positive (Ramblers & Macmillan Cancer Support, n.d.). Walking within groups can create a supportive social environment because they can receive support and information from each other while walking with friends and family members (Housemann & Saint Louis, n.d.).

The respondents from the different age groups in this study showed they prefer using footpaths that walk through forest areas for exercise or training. From here, we can know that respondents prefer exercising in natural areas. Exercise in natural areas with lots of green vegetation also known as green exercise. It can help people reduce their stress and make them feel good. According to the research done by Pretty *et al.* (2005), they found that exercise in rural areas has the greatest effect in reducing their blood pressure. Therefore, the probability of people getting mental and physical health diseases can be reduced by regularly doing green exercise.

Although respondents in this study showed they most like to walk through the forest areas, they also preferred walk through the sightseeing places and places that they can enjoy the delicious local foods. According to the research done by Leask, (2016), the heritage sightseeing places such as castles, historic building, monuments, and visitor centers were attracting the most of visitors to visit. Follow by the natural areas such as forests, national parks and gardens as well as museums and galleries that related to art, cultural, historical and others. Therefore, footpath routes that walk through forest areas and sightseeing areas can attract more people to using it.

For the statement of "Preferable length of footpath", the respondents from different age groups have their own preferable length of footpaths. Young adult group preferred shorter length of footpaths (3-5 km) because they can spend their time in doing other vigorous physical activities that older adult groups not able to do. According to the studies done by Joseph & Zimring (2007), the characteristics of paths that preferred by the older adult groups for recreational walking were long distance, well connected; don't have steps and present of attractive views along the walking paths.

For the statement of "Preferable type of footpath", loop (circular) types of footpaths are more popular than linear (point to point) type of footpaths. This is because the loop type footpath convenient for some footpath users who come by their own transport. If they walk on linear type footpath, they need look for other transportation to go back to their original place. It takes time and costs money. Respondents prefer loop type footpath because it can lead back users to the original starting point of the footpath. Loop type footpath is more attractive because users do not have to walk back to their starting place. Besides, it is also can reduce the physical impact on the footpath and its environment.

Respondents also preferred start and goal of footpath located in a train station or bus stop. This is because it can let people access easily to those places by using public transport. Hirano & Izumi, (2012) also stated that setting the start and finish point of footpaths in JR train station in rural areas can prevent the operating of the local JR line getting worse. In order to attract more visitors visit those areas by using footpaths, JR Company should cooperate with Japan footpath organization to make an advertisement about footpaths inside the train and also train station.

For the preferable type of footpath surface, respondents preferred walk in a mixture of several types of the footpath surface because they will perceive less stress and negative effect when they walking on different types of natural environments such as beach, forest/ woodland, farmland if compared walk in specific types of footpath surface in an urban environment (Marselle *et al.*, 2013).

5.1.2 Preferable characteristics of footpath map and sources to get the footpath maps and information by the different age groups

From the result of questionnaire survey, we can conclude that the respondents from the different age groups considered the location of sightseeing places, toilets, resting points, bus stops or train stations were important to be included in footpath map. The scenic views along the paths and presence of free and convenient places in rural areas for people to exercise are the important factors to let people to use it (Brownson *et al.*, 2000). Therefore, the location of sightseeing places and available facilities along the footpaths are important and it should be visualized on the footpaths map in order to attract more people to use it.

In my opinion, respondents from different age groups still like using a paper map instead of using digital map because people maybe will face the problem of technical difficulties with apps or smartphone running out of battery power. Paper map was preferred by users when they are traveling on foot because it is more durable and portability (Ortiz, 2013).

From the result of questionnaire surveys, different age groups received the footpath maps and information from the different sources. In order to promote more people using footpaths, footpath maps and information should available in the internet (Footpath websites) for young adults and middle-aged groups instead distribute by footpath walking organization only. This is because some footpath walking events and maps in Sapporo are not free. These reasons maybe causing the lower response of young adults involve themselves in the footpath walking activity. Therefore, a footpath walking activity that free of charge should be frequent organize to attract more young people who have an interest in the footpath walking activity.

Besides, marketing activities should promote to increase awareness of people on the importance of using the trails especially people with low physical activity. According to research that done by Reed *et al.* (2004) also stated that there were low levels of use of trails and residents around the study area have low awareness of the availability of existing trails. Therefore, it is important to promote the new footpaths when it is introduced in particular residence areas.

5.1.3 The level of agreement of each statement about footpaths and footpath maps by the different age groups

78.5% of the respondents agree it is important to setting up direction signs and information boards along the footpath because the rate of footpath users lost the way can be reduced. Lack of direction signs can cause footpath users difficult to find the correct footpath course's direction (Izumi & Hirano, 2015). Besides, the available of footpath courses information such as length, elevation change, rules, destination and descriptive information of the place of interest allow footpath users to assess whether the footpath is safe and comfort to use (Axelson *et al.*, 1999).

58.5% of the respondents agree need a footpath guide because some footpath courses in Hokkaido don't have footpath maps. So, they will need footpath guide when footpath walking. Besides, questionnaire study done by Izumi (2015) also stated 71% of respondents prefer footpath walking with a guide. There is 66.0% of the respondents agree they would like to participate in local activities. Participating local activities such as fruits picking, soba making and rice planting activities while footpath walking can let footpath

users experience the local lifestyle and help in regional revitalization because the regional economy was stimulated.

91.9% of all of the respondents agree they will need a footpath map when walking on a new footpath course. From here, we can know that the footpath map is very important for footpath users because they don't know the location of the new footpath and sightseeing places along the footpaths. While, 79.8% of the respondents agree that footpath map with a clear theme, pictures and basic information can attract them to use the footpaths. From here, we can know the map is important for footpath users during their footpath walking. This is because map can present information in an effective way and people usually using maps to navigate during their travels (Verka & Angelina, 2008).

5.2 Evaluation of the characteristics of footpaths and footpath maps in Ishikari Subprefecture

5.2.1 DEM

According to Iwao Ogawa, there is an issue of the lack of young people using the footpath nowadays in Hokkaido. Most of the footpath users who join in the footpath walking tours in Hokkaido are older adults. The population of footpath users also is getting older in Hokkaido (Japan Footpath Organization, 2012). Lack of preferable length of footpaths maybe is one of the reasons that young adults don't interest in footpath walking. This is because there are only 4 existing footpaths in Ishikari Subprefecture with length less than 5 km. The choice of preferable length of footpaths for young adults are limited. However, different length of footpaths is available in Ishikari Subprefecture and allow different age groups choose their preferable length of footpaths.

Extract by mask tool in the GIS Spatial Analyst Toolset was used in this study because it can visualize the footpaths with the different level of steepness. DEM is a good elevation data for landscape analysis in GIS. Footpath slope change maps are useful for footpath users because it allows people to know the level of steepness of the footpaths easily and they can choose to use which footpaths according to their physical ability and purpose. DEM data were used in the research of Hutton (2010) to produce Mountain Bike slope change trail

map using GIS in order to let riders to know the difficulty level of the trails.

The 24 footpaths in this study were considered easy to walk and suitable for everyone from the elevation change and slope gradient. Footpath routes with less than 3 degrees of slope are classified as "Easy" footpath (Kokkinidis *et al.,* 2013). This is because the average slope of the footpaths in this study area is less than 1.66 degrees of slope. Therefore, existing 24 footpaths in Ishikari Subprefecture not only for footpath walking and sightseeing purpose but also suitable for organizing health walks activities. All of these footpaths can be a good place for different age groups to exercise and walk in order to improve their fitness levels and overcoming health issues.

5.2.2 Land use data

The total land use composition along footpaths in Ishikari Subprefecture mostly are building areas (34.95%). According to Ogawa Iwao, the footpaths in Hokkaido have classified into five types which is footpath near the city area, footpath in rural or agricultural areas, restoration route of mountain footpath, animal trails and footpath in abandoned railways (Hamada, 2013). We can conclude that existing footpaths in Ishikari Subprefecture are footpaths located near the city areas and the rural or agricultural areas.

From the table 5.1, the total forest area in Isikari Subprefecture is 58.8%. However, the total forest land use composition along the footpaths in this study is only consists of 10.93%. In my opinion, other new footpaths in Ishikari Subprefecture should be planned in more forest areas that allow people to trespass. Troped (2011) also stated that footpaths that located within area with high levels of population density and greenness can attract more people to use it. Therefore, footpaths that consist of high percentage of forest or greenness areas in the city or rural areas can attract more people to come and use it.

Table 5.1 Forest area in Ishikari Subprefecture, 2015 (Ishikari Subprefectural Bureau, 2016)

City/ Village	Municipality zone area (ha)	Total forest area (ha)	Ratio of Forest area (%)
Sapporo	112,126	71,205	63.5
Ishikari	72,242	53,218	73.7
Ebetsu	18,738	2,011	10.7
Eniwa	29,465	18,815	63.9
Kitahiroshima	11,905	4,356	36.6
Chitose	59,450	32,039	53.9
Tobetsu	42,286	26,288	62.2
Shinshinotsu	7,804	205	2.6
Total	354,016	208,137	58.8

Footpath with high land use diversity index probably will attract more footpath users to use it. This is because footpath users can enjoy footpaths that walk through different landscapes and allow them able to experience different scenery from different land use. Respondents of questionnaire survey in this study also stated they preferred walk through several types of footpath surfaces. According to the research done by Oliver *et al.* (2011), people who live in areas with low land use mix and institutional land uses are showing low interesting on leisure walking. Therefore, it is believed that low land use diversity will reduce the number of people using the existing footpaths in Ishikari Subprefecture.

5.2.3 Existing footpath maps

Most of the footpath users from the different age groups preferred loop type footpaths. However, the number of loop and linear types of footpath in this study are almost same. Although most of footpath users preferred loop type footpaths but sometime the distribution of regional sightseeing places can affect the type of footpaths during planning. Linear type of footpaths usually designed when it may take too long time to return to the starting point.

Evaluation of the available of regional resources and facilities based on the existing footpath maps allowed people to know any insufficient information consisted in the existing footpath maps which respondents in this questionnaire survey considered it is important to be included in the footpath maps. Therefore, improvement of the particular footpath maps in the aspect of available of regional resources and facilities along the footpaths can be suggested in order to let footpath users easily to receive the required information from the footpath maps.

Available of the regional resources and facilities such as bus stops, train stations, sightseeing places, toilets and rest places along the footpaths are considered importance geographical information to be included in footpath maps. Empirical studies also showed there are large cross-sectional relationships between the built environments and walking behavior (Sun *et al.*, 2014). Built environment refers to human-made infrastructure to support human activity such as buildings, parks, roads and others. Therefore, availability of recreational infrastructure or facilities along the existing footpaths in Ishikari Subprefecture will encourage more people to use it.

GIS is a useful tool in this study because the location of regional resources and facilities along the existing footpaths in Ishikari Subprefecture can be created and recorded. Cavnar *et al.*, (2004) also stated that understanding of the location and distribution of recreation facilities through GIS can help authorities or organizers in organizing more effective activities that can encourage people involve themselves in physical activities.

5.3 New footpath route planning for young adults around Oasa Station, Ebetsu using ArcGIS Network Analyst

In this study, GIS was applied in the footpath studies such as footpath planning. In the preview studies by other researchers, GIS was usually used for footpaths regional resources discovering and recording in order to allow people can check where is the most suitable place for locating the rest places, start is and finish points and information boards during planning new footpath routes. In addition, GIS also used for examination of footpath routes in the aspect of the landscape (Imai, n.d.).

The ArcGIS network analyst was used in this study to create the optimal footpath route for the young adult group because network analyst usually used for routes analysis and planning. For example, Chiou *et al.*, (2010) using network analyst in GIS to plan the optimal travel routes by using forest trail network data in Taiwan Sitou Nature Educational Area. Therefore, this GIS analyst is possible to apply in the current footpath route planning.

The ArcGIS network analyst able to compute and plan the shortest footpath route (less than 5km) and passing through sightseeing places and other areas that preferred by the young adult group in this study in an effective way. Network analyst was used in this study instead of Least Cost Path analysis because it would not create many combinations of routes between the selected stops. Network analysis can go through all the selected stops in an optimal order and avoid footpath routes connection with high cost (Petrasova *et al.*, 2015) because network analysis finds the route by calculating the minimum cumulative impedance (distance) between the nodes on the road network dataset (Kumar & Kumar, 2016). Therefore, make sure the connectivity between node and the node of the road network dataset is very important in order to perform efficient and effective network analyst in this study.

In this network analysis study, the stops for the route planning were located in sightseeing places and places that can enjoy the scenic views. This is because footpaths that walking through sightseeing places and scenic views as well as having recreational facilities can stimulate interest of people to visit and using those footpaths. A study of urban trails in Los Angeles, Chicago and Dallas found that trail characteristics and availability of recreational facilities such as toilets, cafes, streetlights and drinking fountains along the trails have a

positive relationship with the frequency of trail use (as cited in Troped, 2011).

Visitors usually prefer using trails in natural areas with unpaved and natural-looking. However, the respondents in this study preferred walk through paved and unpaved footpaths. Footpaths that planned in this study don't use only trails in forest areas but also other paved ways such as roadside paths. This condition is believed can reduce the impact of the unpaved trails. The reason is there are many cases of unpaved recreational trails facing of trail degradation problems such as soil erosion. Therefore, footpath planning should be planned carefully because footpath routes surface with unpaved are susceptible to different impacts such as vegetation loss, erosion, muddiness, widening of the path and so on (as cited in Marion & Leung, 2001).

5.4 Research limitations

5.4.1 Questionnaire survey

The limitation of questionnaire survey is the number of different age groups who respond to this questionnaire survey are not equal. For example, the number of young adults (21 people) and middle-aged (15 people) who respond to this questionnaire survey are too few compared to older adults (58 people). Therefore, the problem of unequal and low numbers of sample sizes of particular sample groups are occurring in this study and it will cause the outcome is not so accurate and limiting us to gain reliable insights. In the aspect of answering the questionnaires, some respondents in this study were not so willing or skipped to answer in some questions. Missing answers, randomly or incorrectly filled in the answers will affect the quality of the data that obtained in this questionnaire survey. Besides, for closed-ended questionnaire, the responses of respondents are limited to the answers that listed in the questionnaire survey only.

5.4.2 Footpaths

a) Available of footpath routes data

The limitation about footpaths is are not all of the footpaths data in this study can be obtained freely because some of the footpath maps and the information of particular footpaths are not available or not completely distributed in the websites. People cannot get the particular footpath route information through the web sites except join the footpath walking tours that organized by particular NPO such as Eco Network. This is because footpaths walking activities in Hokkaido usually organized by NPO and they bring people who interest to walk along the footpaths in particular areas.

b) Footpaths data sharing on open data platforms

Another limitation is some footpath routes usually trespassing to some private land areas and sometime there is an issue about landowners not willing to share the footpath routes that passing through their lands in open data platforms. According to Ogawa Koichiro, there are some land owners not willing let people to know the footpath routes that passing through their land areas. Therefore, footpath routes data sharing through the open data platforms such as OpenStreetMap in order to let more people know the footpath routes is difficult to achieve. Besides, data sharing of footpath routes on specific open data platforms should be updated frequently when there is new facilities or sightseeing areas appear or closed along the footpath routes.

5.4.3 ArcGIS network analyst

There is some limitation for the creation of optimal footpath routes using ArcGIS network analyst. First, the road network data that downloaded from OpenStreetMap (OSM) maybe not so complete such as lack of connectivity of particular walkways in parks and roadside walkways. Second, currently ArcGIS network analysis can only set one cost attribute in the network dataset to find the optimal route in footpaths planning. Therefore, network analyst is hard to apply in visitors who consider routes planning with multiple purpose in the real-life. Therefore, there is only one cost attribute which is the shortest distance of the routes considered in this study.

CHAPTER 6 CONCLUSION

Questionnaire survey in this study showed that both of the age groups have the different perspectives to the preferable length of footpath only. Whereas, respondents from the different age groups have the same preferable characteristics of footpaths such as theme, type, place to start or finish points, and type of the footpath surface. They also have the same perspectives on the preferable characteristics of footpath maps such as type of geographic information important included in maps and type of footpath maps. This study has contributed more data on footpaths studies about preferable characteristics of footpaths and footpath maps by different age groups.

GIS analysis using DEM and land use data in the evaluation of the characteristics of the 24 footpaths and footpath maps allowed footpath users have a better understanding on existing footpaths in landscape aspect through the creation of footpath data sheets. Existing footpaths in this study are considered easy to walk according to the slope change maps and it is suitable for people ranged from children to old people for sightseeing and leisure walking. Besides, existing footpaths in Ishikari Subprefecture located near the city areas and the rural or agricultural areas. For evaluation of footpath maps, people can know what types of geographical information (public transportations, sightseeing places, toilets and rest places) insufficient or not mapped in the existing footpath maps. An improvement based on the result of questionnaire survey for the existing footpaths in the future maybe can attract more young adults involve themselves in footpath walking activities.

The ArcGIS network analyst was used in this study and the shortest distance of footpath preferred by young adults that pass through selected sightseeing places and recreational facilities in Ebetsu was planned and proposed. GIS allows footpaths management, maintenance and planning as well as updating and creating of footpath maps in an effective way and save time. Planning footpaths for young adults according to their preference can attract more young adults involve themselves in footpaths walking activities. Therefore, the purpose of footpaths planning in Hokkaido, which is regional revitalization and promote rural tourism can be achieved soon with the participation of young adults.

In conclusion, questionnaire survey is the relatively cost effective way in collecting large amounts of data from target people in a short period of time. Whereas, GIS is a useful tool for the 24 footpath courses analysis, visualizing and planning because GIS are computer-based maps that display data about terrain, natural resources and man-made features in the correct geographic positions as in the real world. The importance of GIS in the footpath studies will continue increasing in the future.

Appendix A

Footpaths questionnaire survey

Respondents Background

1. Gender:
   ① Male ② Female

2. Age (years):
   ① 10-19 ② 20-29 ③ 30-39 ④ 40-49 ⑤ 50-59 ⑥ 60-69 ⑦ Above 70

3. Please write down your city of residence

4. How often do you use the footpath?
   ① Never use ② Once per year ③ Once per half year ④ Once per every three months ⑤ Once per month ⑥ Two times above per month

5. How do you prefer to use the footpath?
   ① Alone ② With friends and family ③ Walking group / tour ④ Others (_____)

6. What is/are the purpose of you using the footpath? (Multiple choice is possible)
   ① Recreation (to enjoy beautiful landscapes)
   ② Exercise/ Training
   ③ To experience the life of local people
   ④ Interaction (To know more new friends)
   ⑤ Environmental Education
   ⑥ Others (_____)

Characteristics of preferable footpath

7. Preferable themes of footpath? (Multiple choice is possible)

- Sightseeing places ☐
- Forest (Primary, secondary forest, afforested area) ☐
- Agricultural land (paddy, rice fields) ☐
- Wetland, Grassland ☐
- Delicious Local foods ☐
- Urban Area ☐
- Universities ☐

8. Preferable length of Footpath?

① Less than1 km (around 20 minutes)
② 1-3 km (around 1 hours)
③ 3-5 km (about 2 hours)
④ 5-7 km (around 3 hours)
⑤ 7-10 km (around 3.5 hours)
⑥ More than 10km (more than 3.5 hours)

9. You prefer footpath to be/ preferable type of footpath

① Loop (circular)
② Linear (Point to point)
③ Both

10. Which place do you prefer become a start/goal for footpath walking?

① Train stations/ Bus stations
② Universities
③ Shops (such as supermarket)
④ Parks
⑤ Others (_____)

11. Preferable type of footpath surface

① Soil road and Grassland ② Gravel road and Asphalt ③ Mixture of several types

About Footpath map

12. Are the geographical information below important to be included in the footpath map? (Multiple check is possible)

Location of toilets ☐
Location of convenient stores ☐
Location of resting places ☐
Location of car parking lots ☐
Location of bus stops/ train stations ☐
Location of sightseeing places ☐
Others (_____)

13. What kind of footpath map that you prefer use during footpath walking?

① Paper map
② Digital map that can displayed by smart phone or tablet (I- Pad)
③ Both

14. Usually where you get the footpath map and information from?

① Internet/ footpath website (homepage)
② Magazine/books
③ Footpath walking tour
④ Others (Example:_____)

The level of agreement of each statement about footpaths and footpath maps

15. Do you agree that setting up direction signs and information boards for a particular area along the footpath are important?

① Strongly agree ② Agree somewhat ③ Uncertain ④ Disagree somewhat ⑤ Strongly Disagree

16. Do you agree that you need a footpath walking guide when walking along the footpath?

① Strongly agree ② Agree somewhat ③ Uncertain ④ Disagree somewhat ⑤ Strongly Disagree

17. Do you agree that you prefer footpath walking and participate in local activities (fruits picking in local fruit garden or soba making class or others) instead of footpath walking only.

① Strongly agree ② Agree somewhat ③ Uncertain ④ Disagree somewhat ⑤ Strongly Disagree

18. Do you agree you will need a footpath map when walking on a new footpath course?

① Strongly agree ② Agree somewhat ③ Uncertain ④ Disagree somewhat ⑤ Strongly Disagree

19. Do you agree that footpath map with a clear theme, pictures and basic information can attract you to use that footpath?

① Strongly agree ② Agree somewhat ③ Uncertain ④ Disagree somewhat ⑤ Strongly Disagree

20. Please state opinion or request about the footpath map and others.

Appendix B

Calculation of the Chi Square observed and expected value of statements for single response questions

Age groups		**Young adults**	**Middle-aged**	**Older adults**	**Total**	**p value (Chi-square Test)**
Statement: How often do you use the footpath?						
Never use	Count	8	7	6	21	0.238
	Expected count	5.8	6.3	8.9	21.0	
Sometime use	Count	2	7	6	15	
	Expected count	4.1	4.5	6.4	15.0	
Often use	Count	16	14	28	58	
	Expected count	16.0	17.3	24.7	58.0	
Total	Count	26	28	40	94	not statistically significant
	Expected count	26.0	28.0	40.0	94.0	
Statement: How do you prefer to use the footpaths?						
Alone	Count	4	10	3	17	0.269
	Expected count	3.6	8.6	4.8	17.0	
With friends and family	Count	4	6	1	11	

	Expected count	2.4	5.6	3.1	11.0	
Walking group/ tour	Count	8	22	17	47	
	Expected count	10.0	23.8	13.2	47.0	
Total	Count	16	38	21	75	not statistically significant
	Expected count	16.0	38.0	21.0	75.0	
Statement: Preferable length of footpaths						
Less than 3 km	Count	4	0	0	4	0.0006
	Expected count	0.9	0.62	2.4	4.0	
3-5 km	Count	9	3	8	20	
	Expected count	4.7	3.1	12.2	20.0	
5-7 km	Count	6	6	22	34	
	Expected count	7.9	5.3	22.8	34.0	
7-10 km	Count	1	1	24	29	
	Expected count	6.8	4.5	17.7	29.0	
More than 10 km	Count	1	1	1	3	
	Expected count	0.7	0.5	1.8	3.0	
Total	Count	21	14	55	90	Statistically significant
	Expected count	21.0	14.0	55.0	90.0	

Statement: Preferable type of footpaths						
Loop (circular)	Count	19	11	40	70	0.256
	Expected count	17.3	9.9	42.8	70.0	
Linear (Point to point)	Count	2	1	12	15	
	Expected count	3.7	2.1	9.2	15.0	
Total	Count	21	12	52	85	not statistically significant
	Expected count	21.0	12.0	52.0	85.0	
Statement: Preferable place for start/ goal of footpaths						
Train/ Bus stations	Count	16	9	39	64	0.469
	Expected count	17.9	8.5	37.5	64.0	
Universities	Count	1	1	1	3	
	Expected count	0.8	0.4	1.8	3.0	
Parks	Count	3	0	4	7	
	Expected count	2.0	0.9	4.1	7.0	
Others	Count	1	0	0	1	
	Expected count	0.3	0.1	0.6	1.0	
Total	Count	21	10	44	75	not statistically
	Expected count	21.0	10.0	44.0	75.0	

						significant
Statement: Preferable type of footpath surface						
Soil road and Grassland	Count	6	4	13	23	0.919
	Expected count	5.4	3.4	14.2	23.0	
Gravel road and Asphalt	Count	1	0	2	3	
	Expected count	0.7	0.4	1.9	3.0	
Mixture of several types	Count	14	9	40	63	
	Expected count	14.9	9.2	38.9	63.0	
Total	Count	21	13	55	89	not statistically significant
	Expected count	21.0	13.0	55.0	89.0	
Statement: Preferable type of footpath map						
Paper map	Count	14	11	49	74	0.068
	Expected count	16.5	11.8	45.7	74.0	
Digital map	Count	2	0	0	2	
	Expected count	0.4	0.3	1.2	2.0	
Both	Count	5	4	9	18	
	Expected count	4.0	2.9	11.1	18.0	
Total	Count	21	15	58	94	not

	Expected count	21.0	15.0	58.0	94.0	statistically significant
Statement: Usually where you get the footpath map and information						
Internet/ footpath website	Count	12	5	9	26	0.020
	Expected count	7.3	3.7	15	26.0	
Magazine/ books	Count	0	1	3	4	
	Expected count	1.1	0.6	2.3	4.0	
Footpath walking tour	Count	5	4	27	36	
	Expected count	10.1	5.1	20.8	36.0	
Others	Count	3	0	2	5	
	Expected count	1.4	0.7	2.9	5.0	
Total	Count	20	10	41	71	not statistically significant
	Expected count	20.0	10.0	41.0	71.0	

Age Groups		Level of Agreement			Total	P Value (Chi-square Test)
Statement: Do you agree setting up direction signs and information boards along footpaths are important?		Agree	Uncertain	Disagree		
Young Adults	Count	20	0	1	21	0.058
	Expected count	16.5	2.0	2.5	21.0	
Middle-aged	Count	9	4	2	15	
	Expected count	11.8	1.5	1.8	15.0	
Older Adults	Count	44	5	8	57	
	Expected count	44.7	5.5	6.7	57.0	
Total	Count	73	9	11	93	not statistically significant
	Expected count	73.0	9.0	11.0	93.0	
Statement: Do you agree need a footpath guide when walking along footpath?						
Young Adults	Count	11	7	3	21	0.864
	Expected count	12.3	5.8	2.9	21.0	
Middle-aged	Count	9	3	3	15.0	
	Expected count	8.8	4.1	2.1	15.0	
Older Adults	Count	35	16	7	58	

	Expected count	33.9	16.0	8.0	58.0	
Total	Count	55	26	13	94	not statistically significant
	Expected count	55.0	26.0	13.0	94.0	
Statement: Do you agree you prefer footpath walking and participate in local activities?						
Young Adults	Count	14	4	3	21	0.259
	Expected count	13.9	2.7	4.5	21.0	
Middle-aged	Count	11	3	1	15	
	Expected count	9.9	1.9	3.2	15.0	
Older Adults	Count	37	5	16	58	
	Expected count	38.3	7.4	12.3	58.0	
Total	Count	62	12	20	94	not statistically significant
	Expected count	62.0	12.0	20.0	94.0	
Statement: Do you agree you will need a footpath map when walking on a new footpath course?						
Young Adults	Count	20	0	1	21	0.317
	Expected count	19.2	0.9	0.9	21.0	
Middle-aged	Count	13	2	0	15	

	Expected count	13.7	0.6	0.6	15.0	
Older Adults	Count	53	2	3	58	
	Expected count	53.1	2.5	2.5	58.0	
Total	Count	86	4	4	94	not statistically significant
	Expected count	86.0	4.0	4.0	94.0	
Statement: Do you agree that footpath map with a cleat theme, pictures and basic information can attract you to use that footpath?						
Young Adults	Count	15	4	2	21	0.718
	Expected count	16.8	3.1	1.1	21.0	
Middle-aged	Count	13	2	0	15	
	Expected count	12.0	2.2	0.8	15.0	
Older Adults	Count	47	8	3	58	
	Expected count	46.3	8.6	3.1	58.0	
Total	Count	75	14	5	94	not statistically significant
	Expected count	75.0	14.0	5.0	94.0	

Appendix C

Calculation of the Shared (C) in Jaccard Simmilarity Index of statements for multiple response questions

Shared (C)	Frequency (n)	Recreation	Exercise/ Training	To experience the life of local people	Interaction	Environmental Education
Recreation	54					
Exercise/ Training	62	33				
To experience the life of local people	19	13	8			
Interaction	33	24	17	12		
Environmental Education	12	9	5	4	8	

Shared (C)	Frequency (n)	Sightseeing places	Forests	Agricultural lands	Wetlands, grassland	Delicious local foods	Urban areas	Universities
Sightseeing places	65							
Forests	69	47						
Agricultural lands	33	26	27					
Wetlands, grassland	45	32	40	26				
Delicious local foods	51	34	38	22	28			
Urban areas	20	16	10	6	9	12		
Universities	13	11	11	9	7	7	4	

Shared (C)	Frequency (n)	Toilets	Convenient stores	Resting points	car parking lots	bus stops/ train stations	sightseeing places
Toilets	83						
Convenient stores	15	14					
Resting points	73	66	11				
car parking lots	22	19	9	17			
bus stops/ train stations	56	51	11	45	17		
sightseeing places	74	66	11	57	14	43	

Appendix D

The summary of the surface information (Elevation and slope) of the footpaths in Ishikari Subprefecture

Name of footpaths	Surface Length (m)	Maximum Elevation (m)	Minimum Elevation (m)	Mean Elevation (m)	Elevation Range (m)	Maximum Slope (degree)	Minimum Slope (degree)	Average Slope (degree)
Eniwa Igirigawa	4921.75	25.78	14.80	19.61	10.98	4.35	0.00	0.29
Eniwa Kashiwagigawa	7222.92	24.95	9.80	14.92	15.15	3.35	0.00	0.31
Eniwa Moigirigawa	6052.12	54.76	19.85	34.81	34.91	4.46	0.00	0.57
Eniwa Old Shimamatsu Station	10097.17	64.70	14.30	28.63	50.40	29.84	0.00	1.66
Eniwa Osatsugawa	12115.67	52.84	17.57	38.55	35.26	18.16	0.00	0.92
Ishikari Sakyu	9588.38	8.76	0.35	4.43	8.41	7.57	0.00	0.54
Ishikari Shinkawa Kawaguchi	1973.78	5.59	1.26	4.04	4.32	3.67	0.00	0.30
Ishikari Shinkohigashi	12353.94	7.44	0.64	4.62	6.90	5.85	0.00	0.40
Gonotomori kyukotonikawa	6832.82	5.80	2.50	4.56	3.30	4.12	0.00	0.15
Soseigawa Yusuichi	12400.37	5.90	2.50	3.73	3.40	0.50	0.00	0.05
Soseigawa Tondebofurin	5500.98	6.20	2.50	3.88	3.70	0.80	0.00	0.11
Takuhoku	7184.73	5.80	3.24	4.26	2.56	0.54	0.00	0.09
Yurigahara Moere	6491.60	9.16	4.55	6.27	4.61	1.17	0.00	0.11

Yurigahara Higashibarato	5206.09	6.00	1.85	3.81	4.15	2.75	0.00	0.28
Teine Hoshioki	6863.19	11.86	4.00	7.04	7.86	3.63	0.00	0.29
Teine	9876.22	13.71	3.35	6.02	10.36	4.12	0.00	0.26
Shinotsu Hyomura 1	5442.83	9.73	5.00	7.24	4.73	1.66	0.00	0.22
Shinotsu Hyomura 2	6264.45	10.00	4.80	7.33	5.20	1.11	0.00	0.31
Shinotsu Hyomura 3	11423.45	10.00	4.30	6.52	5.70	2.75	0.00	0.21
Ebetsu Eki	5032.37	21.15	8.21	12.51	12.94	2.28	0.00	0.32
Nopporo Eki	2322.88	26.62	23.96	25.56	2.66	2.64	0.00	0.47
Oasa Eki	3134.14	55.23	25.68	36.77	29.55	7.28	0.00	1.42
Kitahiroshima	5427.25	81.37	28.86	53.32	52.51	15.31	0.00	1.64
Tobetsu Youth	5950.95	16.26	11.90	14.64	4.36	2.59	0.00	0.25

Appendix E

The percentage of 2014 land use with 100 m buffer of the footpaths in Ishikari Subprefecture

No	Name of footpaths	Paddy fields	Agricultural areas	Forest areas	Bare lands	Building areas	Roads and railways	Open space areas	Water	Beaches	Golf fields
1	Eniwa Igirigawa	0.0	13.7	1.9	17.0	37.1	0.6	16.4	13.3	0.0	0.0
2	Eniwa Kashiwagigawa	9.7	42.6	6.3	1.9	23.9	2.3	2.2	11.1	0.0	0.0
3	Eniwa Moigirigawa	0.0	27.9	7.6	8.0	37.9	2.9	11.9	3.8	0.0	0.0
4	Eniwa Old Shimamatsu Station	4.5	39.5	32.8	0.0	12.1	3.6	5.4	2.1	0.0	0.0
5	Eniwa Osatsugawa	0.0	29.7	31.8	2.4	15.6	4.7	11.5	4.2	0.0	0.1
6	Ishikari Sakyu	0.0	0.0	24.8	16.8	7.4	7.7	10.9	19.8	12.6	0.0
7	Ishikari Shinkawa Kawaguchi	0.0	0.0	42.7	24.3	0.0	0.0	0.0	19.5	13.5	0.0
8	Ishikari	0.0	0.0	12.5	54.4	0.2	1.0	12.9	13.5	5.5	0.0

	Shinkohigashi										
9	Gonotomori kyukotonikawa	0.0	10.1	0.1	0.0	57.9	4.7	16.8	10.5	0.0	0.0
10	Soseigawa Yusuichi	0.0	7.6	1.5	1.2	47.9	6.5	11.9	23.3	0.0	0.0
11	Soseigawa Tondebofurin	0.0	1.2	8.8	0.0	58.6	10.6	5.5	15.2	0.0	0.0
12	Takuhoku	4.4	7.9	7.3	0.0	47.2	5.6	20.0	5.2	0.0	2.4
13	Yurigahara Moere	0.0	38.7	0.0	0.9	9.9	2.9	44.7	2.9	0.0	0.0
14	Yurigahara Higashibarato	0.7	26.7	0.0	2.3	30.3	0.0	9.4	30.6	0.0	0.0
15	Teine Hoshioki	0.0	9.3	9.9	8.1	45.0	8.0	16.1	3.6	0.0	0.0
16	Teine	0.0	3.8	8.8	0.0	52.4	4.7	19.0	11.4	0.0	0.0
17	Shinotsu Hyomura 1	17.6	53.3	1.0	1.4	17.1	0.0	0.0	9.6	0.0	0.0
18	Shinotsu Hyomura 2	4.1	47.9	13.3	0.0	10.1	0.0	0.0	24.5	0.0	0.0
19	Shinotsu Hyomura 3	3.9	29.2	11.0	2.9	1.4	0.0	0.0	51.6	0.0	0.0
20	Ebetsu Eki	0.0	0.0	9.2	0.0	77.0	5.3	6.6	1.8	0.0	0.0
21	Nopporo Eki	0.0	0.0	2.2	0.0	75.9	14.1	7.8	0.0	0.0	0.0
22	Oasa Eki	0.0	0.0	19.5	0.0	56.2	18.8	5.5	0.0	0.0	0.0

23	Kitahiroshima	0.0	0.0	9.4	0.0	70.1	3.6	16.9	0.0	0.0	0.0
24	Tobetsu Youth	6.2	11.1	0.0	0.9	47.4	0.5	9.2	24.7	0.0	0.0
	Total	**2.1**	**16.7**	**10.9**	**5.9**	**34.9**	**4.5**	**10.9**	**12.6**	**1.3**	**0.1**