

S

93201Q



NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Scholarship 2022 Statistics

Time allowed: Three hours
Total score: 32

QUESTION BOOKLET

There are four questions in this booklet. Answer ALL FOUR questions.

Each question is equally weighted.

Write your answers in Answer Booklet 93201A.

Pull out Formulae and Tables Booklet S–STATF from the centre of this booklet.

Show ALL working. Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

QUESTION ONE

- (a) Read Report 1 below and opposite.

Report 1: Livestock farming and fertiliser use

Livestock farming is a widespread use of land in New Zealand and a significant contributor to our economy. Fertilisers add nutrients, such as nitrogen and phosphorus, to soil to improve soil fertility. These nutrients increase the production, growth, and quality of plants. This, in turn, supports animals feeding on these plants, and the intensification of agriculture.

Figure 1: Nitrogen fertiliser sold in New Zealand, 1991–2019

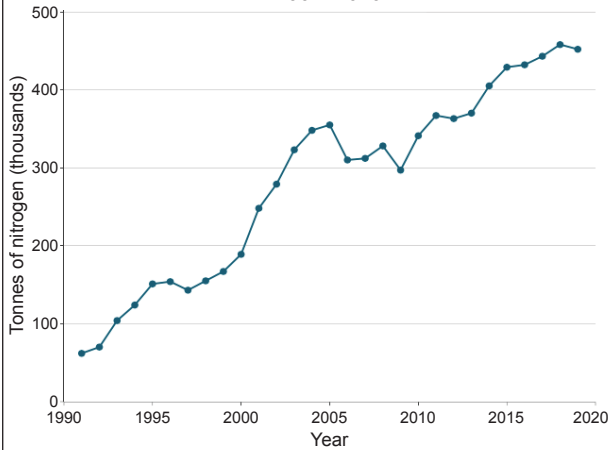


Figure 2: Phosphorus fertiliser sold in New Zealand, 1991–2019

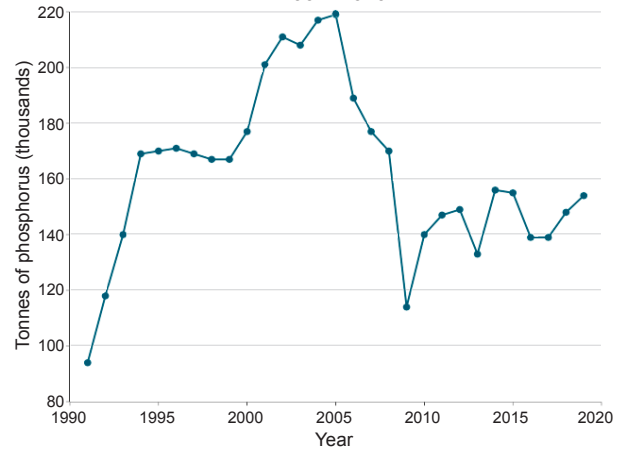


Figure 3: Total farm area in New Zealand, 2002–2019

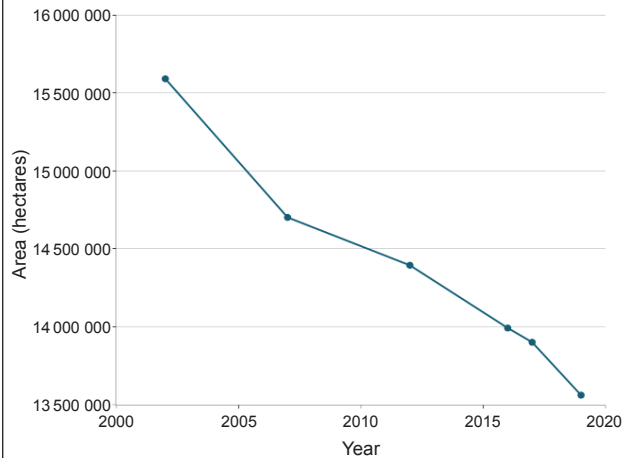
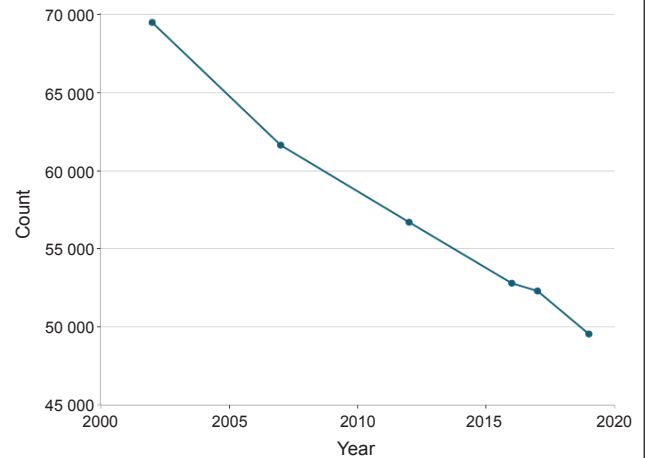


Figure 4: Total farm counts in New Zealand, 2002–2019



Report 1 (cont)

However, livestock can adversely affect the environment, with the extent of impact dependent on the type, size, and animal density. Dairy cattle have a higher environmental impact than beef cattle, and each has a higher impact than sheep. Livestock, particularly cattle, generate methane emissions, which contribute to climate change.

Figure 5: Livestock numbers farmed in New Zealand, 1971–2019

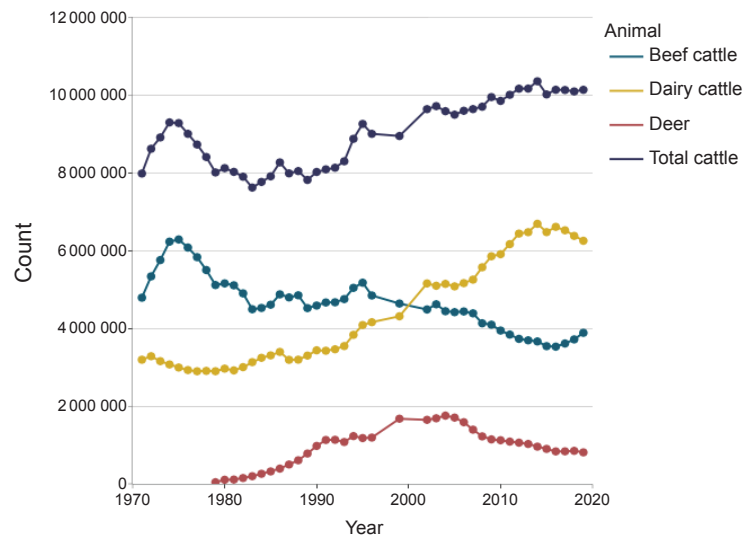
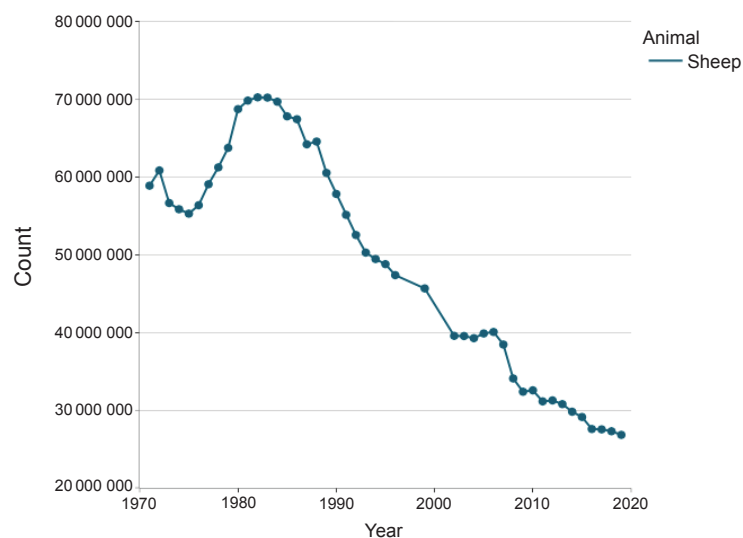


Figure 6: Sheep numbers farmed in New Zealand, 1971–2019



Adapted from information and graphs sourced from Tatauranga Aotearoa (Stats NZ): <https://www.stats.govt.nz/indicators/fertilisers-nitrogen-and-phosphorus>, <https://www.stats.govt.nz/indicators/livestock-numbers>

Write two comments that each compare different features from two or more graphs, and are linked to the information provided in Report 1.

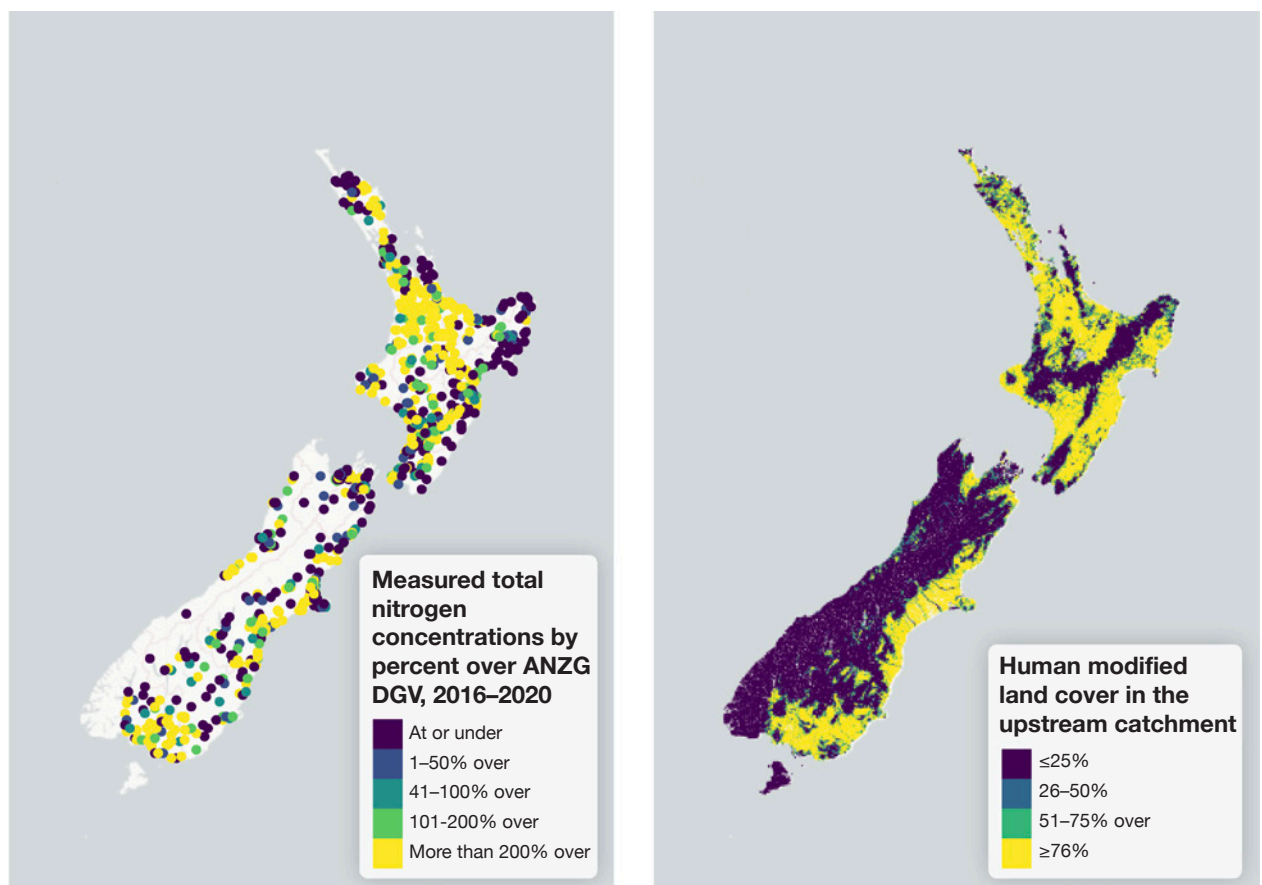
(b) Read Report 2 below.

Report 2: Nitrogen and water quality

Livestock can adversely affect indigenous biodiversity and soil health. Surplus nutrients not absorbed by plants can enter the soil, drain into groundwater, and run off into freshwater bodies, such as streams, rivers, and lakes. This can negatively impact freshwater quality.

The diminishment of water quality is of great concern to Māori and impacts mātauranga (knowledge systems), tikanga (cultural practice), whakapapa (genealogy), and mahinga kai (traditional food resources) connected to water.

Nitrogen in river waters is one of five indicators that provide an overview of New Zealand's river water quality. The concentrations of total nitrogen were measured at monitored sites and compared to the default guideline values (DGV) in the Australian and New Zealand guidelines for fresh and marine water quality (ANZG, 2018), indicating the risk of environmental impairment.



Adapted from information and graphs sourced from Tatauranga Aotearoa (Stats NZ): <https://www.stats.govt.nz/indicators/fertilisers-nitrogen-and-phosphorus>, <https://www.stats.govt.nz/indicators/river-water-quality-nitrogen>

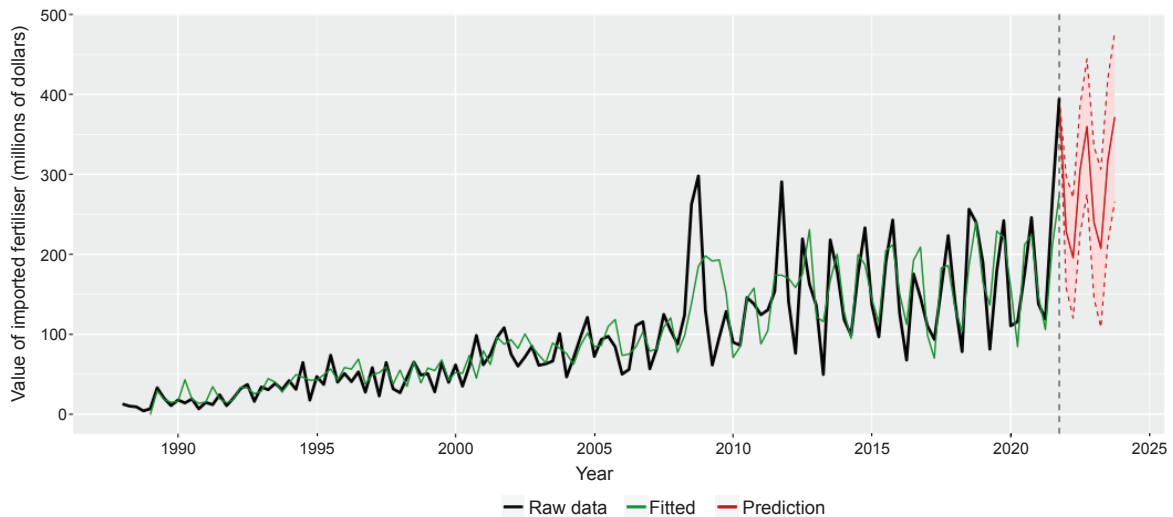
Explain how a graphical technique has been used to visualise the data to communicate the following finding:

Monitored sites with higher proportions of human modified landcover in the upstream catchment area had higher concentrations of nitrogen, compared to sites with lower proportions of human modified landcover.

- (c) Data was obtained from Tatauranga Aotearoa (Stats NZ) on the value of imported fertiliser per quarter, for the years 1988 to 2021. The value of imported fertiliser was measured in millions of dollars.

A student used an additive Holt-Winters model to obtain a forecast for the value of imported fertiliser for the last quarter of 2022. Figure 7 shows the raw and fitted data for the quarters from 1988 to 2021, and forecasts produced from the model (shown in red).

Figure 7: Holt-Winters model fitted to imported fertiliser data



- (i) Write one short paragraph describing the key features of the data for the value of fertiliser imports over the period 1988 to 2021.
- (ii) Evaluate the use of the model to make a forecast for the value of imported fertiliser for the last quarter of 2022, discussing any potential issues with the modelling approach used.

QUESTION TWO

- (a) Livestock, such as cows, are a major contributor to the greenhouse gas emissions from New Zealand and Australia as they produce methane gas when processing their food. With the goal of reducing methane emissions, researchers explored how adding seaweed to the cows' food may reduce these emissions.

Twelve cows were randomly allocated to one of three treatment groups and had either 0% (control), 0.5% (low additive) or 1% (high additive) seaweed included in their feed. The cows were monitored in a barn with individual sensors that measured food intake and methane gas emissions. The experiment was then repeated two more times, so that each cow received all three treatments.

- (i) Explain why each cow received all three treatments.
- (ii) The study found a significant decrease of methane emission in the low additive diet, and a significant decrease in the high additive diet, when compared to the control.

Explain how the researchers could have analysed their data to support this finding.

- (b) Read Report 3 below.

Report 3: Seaweed (karengo) fertiliser game-changer for Kiwi farmers



Adapted from: <https://www.teaomaori.news/seaweed-karengo-fertiliser-game-changer-kiwi-farmers>

Report 3 claims that the seaweed (karengo) fertiliser "... cuts nitrogen in cows' urine by 18%".

Write a short paragraph that describes the key elements of a study design that could be used to investigate this claim, using appropriate statistical terminology.

- (c) Headlines from all articles published from 2018 to 2020 by a New Zealand newspaper were used to explore reporting about climate change. All 261 articles where the headline contained the word 'climate' were used for the data exploration.

The headlines for these articles were analysed using sentiment analysis. Sentiment analysis assigns a score on a continuous scale between 0 and 1 that measures the overall sentiment or emotion of a piece of text. A sentiment score of 0 indicates a completely negative sentiment, and a sentiment score of 1 indicates a completely positive sentiment.

The headlines were then analysed to explore whether the headline also contained the word 'change', and what month the article was published. Figures 8, 9, 10, and 11 show four of the plots produced as part of the data exploration.

Articles containing the word 'climate' in the headline

Figure 8: Month published

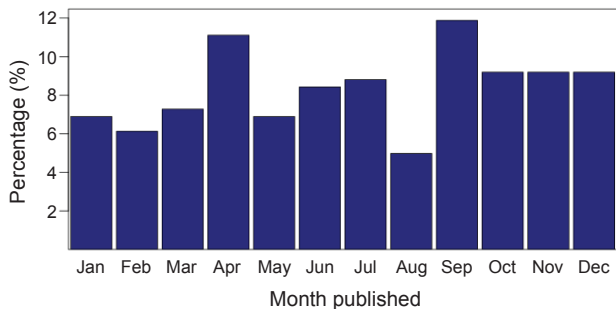


Figure 9: Sentiment score

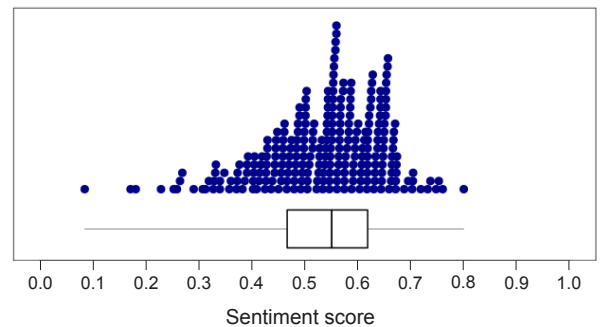
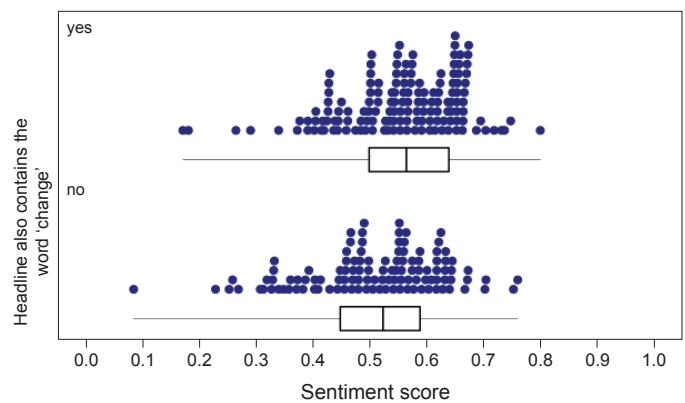
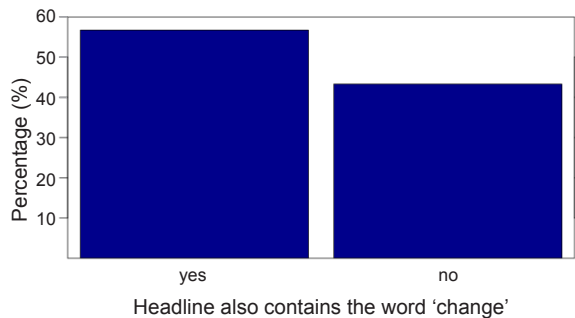


Figure 11: Sentiment score by headline also contains the word 'change'

Figure 10: Headline also contains the word 'change'



Write a short paragraph describing what the plots reveal about these headlines.

QUESTION THREE

- (a) Read Report 4 below.

Report 4: Concern about climate change is at its highest for nearly a decade.

Horizon Research has been tracking levels of public concern about climate change since 2006. Its latest November 2021 survey revealed that 72% consider climate change a problem now. Since 2006, there has been a significant decrease overall in people who believe climate change action can wait: 74% thought that in 2006, but only 24% did in 2021.

Figure 12



The 2021 results are from a survey of 1097 people aged 18 and over, representing the New Zealand adult population at the most recent census.

Adapted from: <https://www.horizonpoll.co.nz/page/629/78-believe->

- (i) The survey claims the 2021 results represent the New Zealand adult population at the most recent census.

Explain how this could have been achieved.

- (ii) Suppose a claim is made that the proportion of New Zealand adults who consider climate change a problem now, has increased with each of these surveys taken from 2012 to 2021.

Evaluate this claim, assuming that the surveys for each of these years were carried out with the same number of people as in 2021.

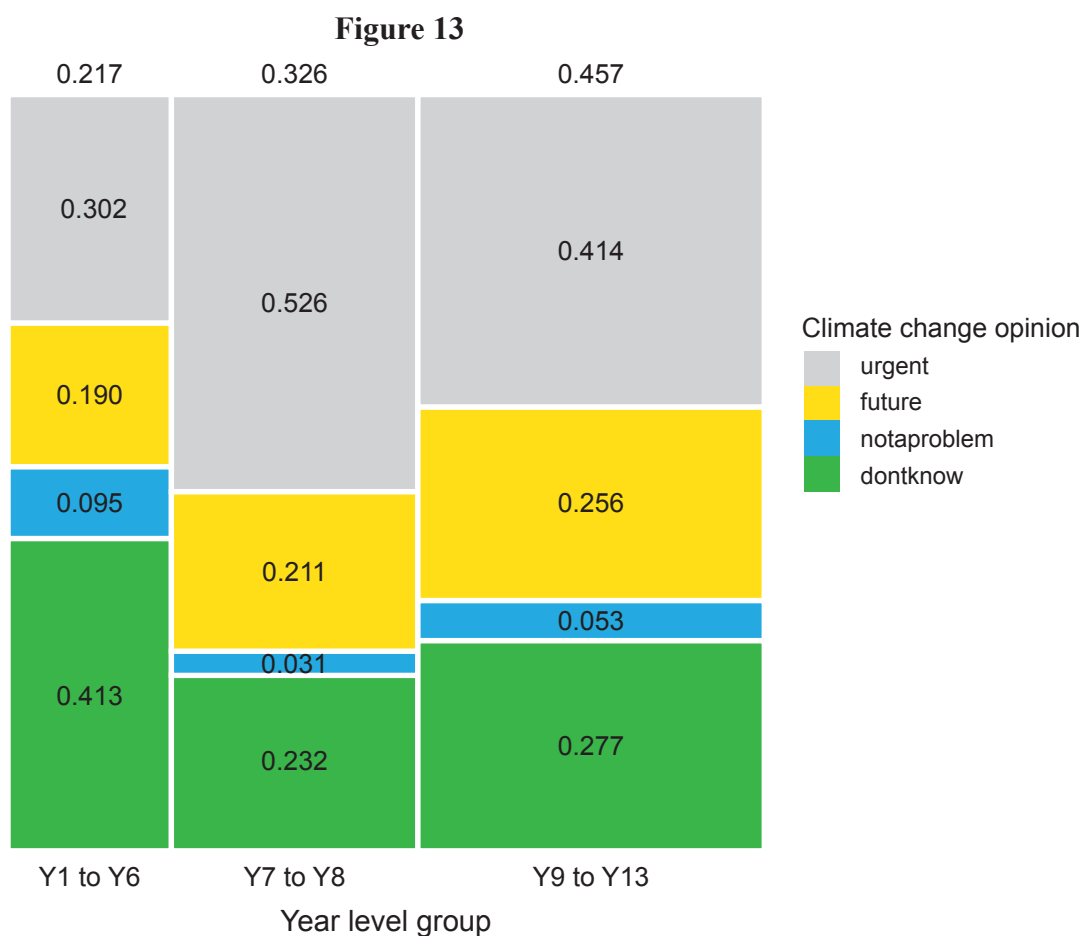
Support your answer with relevant calculations.

- (b) TataurangaKiTeKura Aotearoa (CensusAtSchool New Zealand) has conducted an online survey of school students every two years since 2005. In the 2021 survey, the following question was asked:
Which option best describes your opinion on climate change?

Students had to select one of the following four options for their answer:

- It is an urgent problem that needs to be managed now (urgent).
- It is a problem that needs to be managed in the future (future).
- It is not a problem (notaproblem).
- I don't know or have no opinion (dontknow).

A random sample of 291 students was taken from the 2021 CensusAtSchool data. The year level of each student in the sample was used to create a new variable called **Year level group**. This data has been visualised in the Eikosogram shown below.



An Eikosogram is a graphical representation of a two-way table of proportions. Each rectangle represents one of the cells from the two-way table, and the area of each rectangle represents a relative proportion.

- (i) Based on the data presented, discuss what evidence there is, if any, for the following statement:

New Zealand students who consider climate change is a problem tend to be older than those who do not think climate change is a problem.

Support your answer with calculations.

- (ii) Based on the data presented, explain whether the sample from CensusAtSchool is likely to be representative of students in New Zealand schools in terms of year levels.

QUESTION FOUR

- (a) The issue of climate change has led to rallies, marches, and protests around the world. To measure how many people attend such events, and who they are, data sources such as photographs are often used.



Source: <https://unsplash.com/photos/7SE389kUVGw>

Source: <https://unsplash.com/photos/jXPQY1em3Ew>

Several photos from a climate change march were used to estimate the proportion of school-aged children (5 to 18 years old) who attended the event.

Explain how a statistical inference method could be used to estimate the proportion of school-aged children who attended the event, and describe two potential limitations of using photos as a source of data as part of this method.

- (b) A common approach used to estimate the number of people who attend events, such as marches, is to first estimate the 'crowd density'. The crowd density is the number of people occupying a certain area; for example, 3 people per square metre. The crowd density is then multiplied by the total area occupied by the crowd, to estimate the size of the crowd (the total number of people attending the march).
- (i) Discuss two assumptions that need to be made when using the approach described above to estimate the size of the crowd attending an event.

- (ii) The total area occupied by the people who attended one climate change march was approximately 18 000 square metres. A high-quality aerial photo of the march was divided into squares, with each square measuring 5 by 5 metres.

A random sample of 100 of these squares was selected, and the number of people within each square was counted by a human. The sample was then used to construct a bootstrap confidence interval for the mean crowd density per square, and this interval had limits (20.4, 23.2).

An organiser of the march claimed that over 17 000 people attended.

Discuss whether this claim can be supported by interpreting the confidence interval given above.

- (c) Climate change has been linked to an increase in weather-related natural disasters, such as those involving fires, floods, storms, wind, rain, and other extreme weather events. Te Kāhui Inihua o Aotearoa (the Insurance Council of New Zealand) has recorded information about natural disasters in Aotearoa New Zealand. This information was used to create Figures 14 and 15.

Figure 14: The number of weather-related natural disasters recorded per annum between 1980 and 2020, by year



Figure 15: The number of weather-related natural disasters recorded per annum between 1980 and 2020, by frequency



A student suggests that the number of weather-related natural disasters per annum in Aotearoa New Zealand can be modelled by a Poisson distribution with $\lambda = 4.2$.

Using the data and information provided, discuss whether the probability distribution model proposed by the student is appropriate.

