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"Cultural Heritage Protection in Climate Change"

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Chiara Bertolin **America Califano** **Markus Schwai**

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GROUP 1

The challenges of preventive conservation and discussion of future use regarding the historic warehouses along the Kjøpmannsgata in Trondheim (Norway): consideration of special risks due to ongoing climate change

J. E. Afonso Santana, C. Calapiña Arriaga, M. Klinkert, P. Higgins, L. Vergelli

[HISTORY]

The early Trondheim

In Trondheim, the first recorded human activities can be tracked back ca. around 700 AD.

In the Year 997, when Olav Trggvason ordered the building of a residence and the church of Klemenskiren, which became later the foundation for Trondheim, there were already docks with warehouses towards the water. Since Norways Geography contains mostly of mountans and fjords Trondheim is, together with Oslo, the only place with a continuous form of lowlands.[1]

After the battle of Stiklestad in 1030, Christianity was implemented. Paganism was outlawed and new forms of cities which included churches were able to emerge. The first churches and monasteries in Trondheim were also built during that time.[2]

Figure 1 - Hypothetical Map of early Trondheim[3]

The rise of trading

At the end of the 12th century, more and more different types of buildings were erected; some were used as warehouses others also as homes. Between 1200 and 1400 the population of the city grew steadily. The warehouses played a vital role in the development of the city. Between 1274 and 1276 the King of Norway

Magnus Hakonson Lagabotes issued laws like the "landslov", one of most important laws of medieval Europe. Among other rules and laws there was also a city law specifically for places like Trondheim. This law specifically ordered all merchants that they had to lay down on the piers where they rented a warehouse. It was forbidden to sell goods directly from the boat.[4] This was one of the reasons why the piers with warehouses became the lifeblood of the city.

The piers belonged to the shipowners and wholesalers. Their properties were divided into plots across the river.

The warehouses were not only used for the purpose of fishing and storage, but also some of them had entire farm facilities with residential and private houses, barns, and storage cages. Behind the warehouses there were residential houses constructed in a very cramped way. The Streets were usually build in a tight way, most buildings were made of wood. Only churches and a few other buildings consisted of stone.[5]

During the construction activity in the city, a lot of material was simply dumped into the river and created little islands. Because of that the piers were therefore built further out into the river and thick pawls were lowered to the bottom of the river, so merchants were still able to load and unload their ships. The use of flat jetties made it possible to walk across the river without a boat.[6]

The reconstruction of Trondheim

In 1625 there was also a landslide on the east side of the river. On the new terrain the foundation was laid for what is now Bakklandet.

Figure 2 - Map from 1658 depicting Bakklandet[7]

At that time the piers started to develop their characteristic appearance.

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[1] Thomas Hall- Planning and Urban Growth in the Nordic Countries 1. edition.

[2] Imsen Steinar- The Norwegian Domination and the Norse World, C.1100-c.1400 - Tapir Academic Press.

[3] Troøyen, M. / Johnsen, E.G.: Kjøpmannsgata 27, unpublished Master Thesis, Department of Architecture, NTNU Norwegian University of Science and Technology, Trondheim 2022.

[4] Pål A. Bertnes- Legal information in Norway - electronic and printed sources 5th edition.

[5] Thomas Hall- Planning and Urban Growth in Nordic Countries 1. Edition.

[6] Troøyen, M. / Johnsen, E.G.: Kjøpmannsgata 27, unpublished Master Thesis, Department of Architecture, NTNU Norwegian University of Science and Technology, Trondheim 2022.

[7] Troøyen, M. / Johnsen, E.G.: Kjøpmannsgata 27, unpublished Master Thesis, Department of

From the 15th century on the city's growth stagnated. The powerful Hanseatic League (Hansa Teutonica) decided to choose Bergen instead of Trondheim as their main hotspot for trading.[8] There was also the constant problem of fire outbreaks and the war with Sweden. While this was a problem for many cities in Europe, Trondheim burned down overall 15 times. Usually, the inhabitants just rebuild the damaged and destroyed part of the city again until Major General Johan Caspar von Cicignon ordered the rebuilding of the town. He was deprecatory towards the old medieval style of the city.

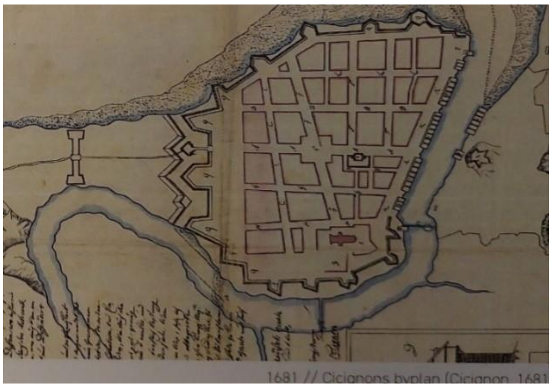

Figure 3 - Plan for reconstruction of Trondheim (1681)[9]

The new Trondheim should be modelled after a more baroque style like Versailles, so it could fit all the military and safety needs. Alongside the river there were streets with trees on both sides so there was an easy access to the warehouses.

Cicignon was also commited to further fortifier Trondheim. However, his plan was only followed partially.[10]

The industrial revolution

Trondheim was able to flourish and Bakklandet was still an important part of the city, until the industrial revolution reached Norway around 1850.

One important factor of the industrial revolution was the population growth. Along with other Norwegian Cities Trondheim underwent changes in infrastructure and urban development. Another way to boost the economic growth was the abolition of former trade restrictions. Together with the industrial revolution bigger ships with a much higher carrying capacity were established. With the consequences that the warehouses were seen as an obstacle to the town's development.

Architecture, NTNU Norwegian University of Science and Technology, Trondheim 2022.

[8] Elisabeth Gee Nash - The Hansa 1995 - Barns and Nobles.

In addition, the new Bakka bridge was also built, which made it difficult for larger ships to sail up to the piers. Trondheim maritime infrastructure needed to be modernized.

After Carl Adolf Dahl´s plan for the modernization of Trondheim was accepted in 1876 and the building of a new harbour, which was in the direction of the fjord meant that the centre urban development shifted away from places like Bakklandet.

After almost 1000 years of being the centre of Trondheim the piers lost its original function, and that also included Bakklandet.[11]

The abandonment and the decay

During the 20th century the warehouses of Bakklandet were still in some form of intermittent use for fishers but they were no longer the central place of the city.

Since they were not used that often anymore the forecourt increased.

They were seen as a problem and in the context of modernism some proposals were made to tear them down. They withstand the second world war without any serious damages and some of them showed signs of decay.

However, with the Midtbyen Plan from 1975 wooden houses were seen as a historic image of the city and it was therefore decided that buildings, like the warehouses of Bakklandet, should be preserved.[12]

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[9] Troøyen, M. / Johnsen, E.G.: Kjøpmannsgata 27, unpublished Master Thesis, Department of Architecture, NTNU

[10] Thomas Hall- Planning and Urban Growth in Nordic Countries 1. Edition.

[11] Thomas Hall- Planning and Urban Growth in Nordic Countries 1. Edition.

[12] Troøyen, M. / Johnsen, E.G.: Kjøpmannsgata 27, unpublished Master Thesis, Department of Architecture, NTNU

[STATE OF THE ART (CONSERVATION STATE - RELATION BETWEEN BUILDING AND ENVIRONMENT - ACTUAL USE)]

In today's Trondheim the influence of the warehouses facing the Nidelva River is profoundly central at the urban level. They are in an enclave influenced by the forced connection between two densely populated districts, the city centre and the Bakklandet district, naturally separated by the river.

In the space between the two main bridges that guarantee this connection and, at the same time, on the west bank of the river, is where the warehouses of greatest historical importance are located, and they are the ones which are the subject of this study.

This front of buildings of Kjøpmannsgata, beyond being a historical landmark in the drawing of the city, is a central point in itself, and it is the image that the city wants to project towards its visitors.

It is important to highlight the relevance of the sector as a whole, beyond the interest of any individual warehouse. That what is presented in this section of the Nidelva river acts like an exposure of a particular constructive and architectural system of continuous application. In addition, it speaks directly of the idiosyncrasy of the city and its deepest conditions and traditions.

Although the sector continues to be an absolutely central point in the city and surely its most visible face; there is a deep conservation problem linked to the disappearance of its original use, that of goods and food storage, and the consequent lack of maintenance and repair tasks directly linked to this commercial activity.

Since the sudden disappearance of the original use of the warehouses caused by the construction of the new wharf, better prepared for larger ships, there has been a prolonged dichotomy between the abandonment of some of the warehouses and the architectural adaptation of the rest to a changing variety of uses. Today this dichotomy still holds, and even does so in a more complex way.

With the development of urban and architectural regulations, the level of intervention and reconstruction with respect to the original state of the buildings has become deeply invasive for most of the proposed and existing uses.

On the other hand, there are initiatives under development for the intensive conservation of the original state of some of the buildings which, however, have great difficulties searching for possible owners who might be interested in a building with a high level of historical responsibility, maintenance and ongoing continuous costs and whose future use and potential long-term profitability from a particular investment point of view are virtually unknown.

With this situation, the establishment of an intermediate situation is of critical importance, where the buildings can be used and have a certain level of economic profitability, but without this implying the loss of the character and original construction system. For this, it would be important to explore new uses, whose adaptation needs were not so far from those of the original use of the building.

The objective of this brief investigation, given this alarming situation (which is also aggravated by the conservation problems linked to climate change), focuses on the study of a series of proposed criteria to study the possible consequences and the level adaptation of possible future uses for these buildings.

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[OVERVIEW OF CLIMATIC PARAMETERS AND COMFORT ISSUES]

__Trondheim “historical” climate and climate change

In Trondheim (coordinates: 63,430-degree latitude & 10,395-degree longitude)the summers are cool, wet, and mostly cloudy and the winters are long, freezing, snowy, and overcast. Trondheim is located near a large body of water (e.g., ocean, sea, or fiord).

Temperature

Over the course of the year, the temperature typically varies from -5°C to 18°C and is rarely below -13°C or above 25°C (Table 1).

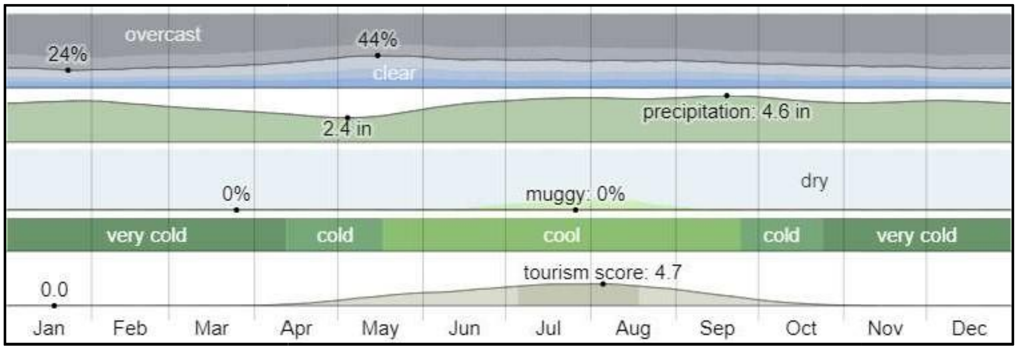
season	average temperature
warm (from June to September)	15°C July (hottest month): high average = 18°C VS low average = 11°C
cold (from November to March)	4°C January (coldest month): high average = 1°C S low average = -4°C

Table 1 – average temperature in warm and cold seasons

Average water temperature experiences some seasonal variations over the course of the year (Table 2).

season	average temperature
warmer water (from July to September)	above 12°C(high average of 14°C in August)
cooler water (from Dece ber to May)	below 7°C (low average of 5°C in March)

Table 2 – average water temperature in warm and cold seasons



Trondheim weather by month. Click on each chart for more information.

© WeatherSpark.com[33]

Precipitation

The wetter season lasts from June to March (the wettest month is September). The drier season lasts from March to June (the months with the fewest wet days in Trondheim are April and May). Among wet days, precipitation may be rain, snow (specifically from October to April), or a mixture of two.

Sun

The length of the day in Trondheim varies extremely over the course of the year (the shortest day in December has got around 4 hours and 30 minutes of daylight; the longest day in June 21 has got around 20 hours and 30 minutes of daylight).

The total daily incident solar radiation (UV and VIS waves) reaching the surface of the ground is a number which considers:

- seasonal variations in the length of the day
- elevation of the Sun above the horizon
- radiation absorption by clouds and other atmospheric constituents.

[13] https://weatherspark.com/y/68746/Average-Weather-in-Trondheim-Norway-Year-Round.

The average daily incident solar radiation experiences extreme seasonal variation over the year.

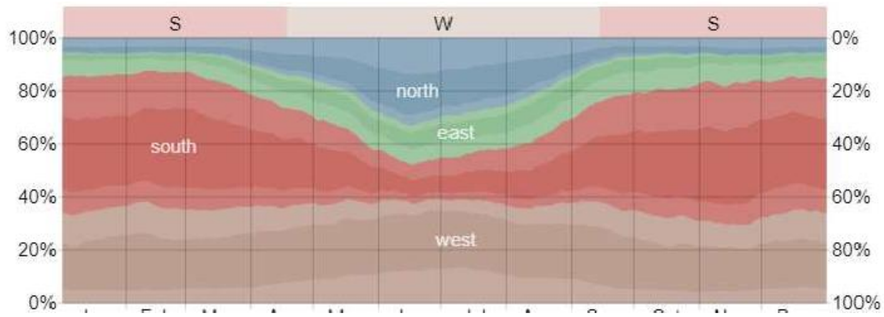
period	average daily incident solar energy per square meter
brighter period (from May to August)	above 4,2 kWh (June, the brightest month, average = 5,2 kWh)
darker period (from October to February)	below 1,1 kWh (December, the darkest month, average = 0,1 kWh)

Table 3 – average daily incident solar radiation in warm and cold seasons

Wind

period	average hourly wind speeds	direction of wind
windier period (from October to April)	more than 10 km/h (January, the windiest month, is 14 km/h)	more often from the south
calmer period (from April to October)	less than 10 km/h (July, the calmest month, is 7 km/h)	more often from the west

Table 4 – average hourly wind speeds in warm and cold seasons



The percentage of hours in which the mean wind direction is from each of the four cardinal wind directions. The lightly tinted areas at the boundaries are the percentage of hours spent the implied intermediate directions (northeast, southeast, southwest, and northwest).

WeatherSpark.com[14]

[14] https://weatherspark.com/y/68746/Average-Weather-in-Trondheim-Norway-Year-Round.

Climate change

In Trondheim the average temperature has not had a sharp increase in the 30 years from 1961 to 1990: only temperature-value dispersion has increased. This datum, confirmed also for the 30 years from 1991 to 2020, means an increase in extreme phenomena (hotter summers VS shorter and colder winters), with the consequent variation in the length of the different seasons. The increase in temperature fluctuations in the first and last months of the year causes freeze and thaw cycles, which usually occur precisely in winter. The cycles are harmful to the materials, e.g., the hygroscopic wood (damage functions).

__Object comfort versus human comfort - challenges and approaches

Built heritage and heritage collections require conservation approaches, which can cause conflict with the demands of human comfort.

Passive environmental control strategies historically focused on the wellbeing of the people who inhabited the buildings. This was at a time, where no electricity and advanced heating methods were available. As a side effect, many of these building constructions were also very conducive to the preservation of the building fabric. Unfortunately, not all of these approaches can be applied to the conservation of cultural heritage. In addition, the official regulations for the use and air conditioning of buildings in terms of health regulations and well-being have become more stringent, which limits the possibilities for using the buildings.

According to ISO 7730:2005[15]the level of comfort for a sedentary activity should be inside the margin between 19°C and 29°C on the floor surface, with the most ideal temperature being around 26°C. One of the main issues in developing suitable conservation concepts is balancing the essential conservation requirements of the objects with the needs of the people who live or work in these buildings. In terms of the challenging Norwegian climate, this makes things even more complicated.

KING and PEARSON discussed this problem in relation to buildings in Australia, but important key messages are applicable to this topic [Pearson *et al.*, 2000[16]].

➔ Objects and buildings are static and cannot move away from an adverse environment. In contrast,humans can adapt to unfavourable climate conditions by changing their location, seeking shelter, or dressing appropriately.

➔ Sensory compensations and comfort preferences by humans can be contrary to the conservation requirements of the historic materials, for example:

O Lowering of relative humidity increases human comfort but hastens the desiccation of wood and leads to mechanical stress in the form of shrinkage and cracking.

O People prefer higher temperatures and may seek out radiant heat sources, which promote intense differential temperature stresses, resulting in strong mechanical strains and increased rates of oxidation.

The recognition that humans are more adaptable to uncomfortable climatic conditions than static objects due to their mobility and flexibility should be taken into account in relation to significant and vulnerable cultural heritage. Therefore, strategies for passive and low energy environmental control can be preferred for providing stable environmental conditions, which might not always match optimal conditions for human comfort. The main tasks are to identify aspects of the building construction which are beneficial for the environmental stabilization and to reduce and modify harmful factors [Pearson *et al.*, 2000[17]].

Summary of conservation requirements, objectives, and possible strategies

General material parameters

The Bakklandet warehouses are mainly wooden timber constructions, built on natural stone foundations, located close at and partly above the river. The foundations (basement) consist of a ring wall made of natural stone masonry, the river fronts are supported by inner and outer rows of massive wooden pillars. The timber constructions are characterized by a high frequency of vertical pillars for stabilization and closely staggered wooden boards around the walls and floors. The ceiling height is low, daylight can only enter most buildings through windows at the riverside and roadside (except warehouses situated next to open places). The buildings contain windows and wooden doors of different sizes and periods. Towards the river side there are large openings and wharves, which were used for loading goods. The roofs are a combined rafter and ridge roof, covered with slate or corrugated iron. Most of the warehouses are painted in different colours; most likely linseed oil was used as a binding agent [Troøyen, M.*et al.*, 2022[18]] .

[15] EN ISO 7730:2005: *Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria* , German version EN ISO, https://www.din.de/de/mitwirken/normenausschuesse/naerg/veroeffentlichungen/wdc-beuth:din21:89417255, accessed on 26.05.2022.
[16] Pearson, C. / King, S.: Passive Environmental Control for Small Cultural Institutions in Australia, in: Australian Academic & Research Libraries, 31/2/2000, pp. 69-78, DOI: http://dx.doi.org/10.1080/00048623.2000.10755117, accessed on 26.05.2022, pp.73-74.
[17] PEARSON / KING 2000, p. 74.
[18] Troøyen, M. / Johnsen, E.G.: *Kjøpmannsgata 27*, unpublished Master Thesis, Department of Architecture, NTNU Norwegian University of Science and Technology, Trondheim 2022.

Risks and vulnerabilities

In order of priority, the risks/vulnerabilities affecting warehouses are:

1) fire: history teaches us that fire has always been the main enemy of wooden warehouses: in presence of wind, the fire can spread from one warehouse to another,affecting the entire structure, from foundations to roof, and damage of wood is irreversible.

2) flood: considering the position of the houses, by the river, with their foundations directly under the water resting on a “quick clay”, the risk of flood occurs whenever the water level of the river rises (due to long periods of rain or due to the melting snow) and, for this reason, the static capacity of the structure is lost. Due to climate change, the risk of floods is now increasing, as it is increasingly frequent the occurrence of extreme weather events.

3) biological infestation: one of the main consequences of elevated moisture/liquid water content (in general high humidity values) is the biological contamination by microorganisms, insects, and other invasive species. Damp wood is vulnerable to attack by mould, bacteria, and pests, whose life cycle is as fast as the conditions are suitable for their growth. The result of climate change is a warmer and more humid climate with the consequent acceleration in biological growth and a higher risk for infestation of structural wood (organic material).

4) exposure to weather: the external surface of the warehouses -roof and facades- in addition to the foundations is obviously subject to the continuous action of external atmospheric agents. The rain, whose direction and force are due to the action of the wind, can be more or less intense. The most exposed portions of wood will be more humid with all the consequent problems related to the water/moisture content inside the structure of the organic material. Climate change (stronger wind and heavy rainfalls/snowstorms) can make the situation worse. In addition, sunlight exposure depends mainly on the season of the year (different inclination of the light rays with respect to the earth's surface) and on the presence or absence of clouds in the air which represent a screen that attenuates the energy carried by the light rays, therefore their intensity. The irradiation of a surface consists in a transfer of heat and therefore in a heating of the irradiated material, in the case of wood the consequences are physical-mechanical stressors (deformations, fractures, cracks, loss of stability). Climate change action consists of an increase in sunlight intensity, thus in the wood decay.

5a) freeze-thaw cycles: Trondheim climate shows severe variations in temperature throughout the year. The problem of freeze-thaw cycles occurs whenever the temperature falls below 0°C (or much below in the presence of salts dissolved in the water) and goes back above 0°C (or above the temperature of transition between liquid water and ice). The consequences of the cycles are minimal if the cycles occur with low frequency over time but become alarming if the freeze-thaw cycles are recurrent (as in the case of the strong fluctuations in temperatures recorded in recent years due to climate changes). The mechanical stress to which the wooden material constituting the structure of the warehouses is subjected is caused by the greater volume occupied by the ice compared to the one occupied by liquid water. The liquid water that infiltrates into the pores and the voids of the wood, becoming ice below 0°C and increasing in volume, causes an increase in the size of the pores and the voids with consequent fractures and cracks. Due to climate change, we observe frequent freeze-thaw cycles also during winter, these are caused by the rise of average temperature.

5b) salt (sub)efflorescence: although there it is river water, its proximity to the sea makes it “mixed” and the capillary rising of salts through liquid water is a natural phenomenon for wet wood. The problem of the cycles increases when the water passes from the liquid form to the vapor form (evaporation) and the salts (mostly chlorides and nitrates) become insoluble in a smaller quantity of water (supersaturation of the solution) and crystallize in the pores and voids of the wood. Repeated cycles over time cause an increasingly marked crystallization. If the evaporation is fast (high temperature and presence of wind) the crystals are small in size and form below the surface → sub-efflorescence, if the evaporation is slow (low temperature, absence of sunlight and wind) the crystals are large in size → efflorescence. The greater intensity of climate fluctuations in temperature and humidity due to recent climate changes results in a greater speed of occurrence of the degradation phenomenon caused by the cycles of saline crystallization and dissolution.

Requirements regarding preventive conservations methods, goals and possible solutions

“Sustainability is the idea of using cunning, looking at what people did in the past, adding that to modern physics, and generally designing things that you're proud of because you didn't drag in a whole lot of electricity and energy." - Tim Padfield[19]”

Considering the climatic risks, material vulnerabilities, heritage value and specific problems related to future uses, there are high requirements in terms of environmental control and preventive preservation. The main aim is to safeguard the warehouses as a cultural heritage while respecting its significance, integrity and authenticity. This includes its accessibility to present and future generations. In addition, in times of climate change and limited energy resources, the reduction of the carbon footprint should be a part of a holistic and sustainable approach. During the last decades, the idea of *Passive Environmental Control* [Pearson *et al.*, 2000[20]]

[19] https://www.getty.edu/conservation/publications_resources/newsletters/22_1/dialogue.html, accessed 29.05.2022.

[20] Pearson, C. / King, S.: Passive Environmental Control for Small Cultural Institutions in Australia, in: Australian Academic & Research Libraries, 31/2/2000, 69-78, DOI: 10.1080/00048623.2000.10755117,

gained more attention, meaning to adjust climate parameters without mechanical facilities and artificial climate control systems but through well thought building design and fabrics with abilities to buffer. The advantages lie in the cost effectiveness, a less complicated installation and maintenance and environmental sustainability, as much less energy is required[21].These passive, non-mechanical methods often include historic and traditional building techniques.

The main aim of passive environmental control strategies lies in the reduction of mechanical strategies and the resulting reliance on constant energy supply and high maintenance. These strategies may be combined, if non mechanical strategies might not be enough [Maekawa*et al.*, 2015[22]]. As a result, energy-consumption, installation, and operating costs can be significantly reduced. As there are no complex machineries to be maintained, the environmental conditions are generally more stable and reliable.

Preventive conservation and passive climate control through appropriate building design are the basis for all further measures. Table 5 summarizes the most important aspects.

Requirement	Specifies	Possible Actions
Fire prevention	- highest priority! - sources of fire need to be avoided at all costs - development of a well thought fire prevention and emergency plan	- no electrical installations and if required: constant maintenance, use of electrical equipment under constant supervision - use of fire-resistant building and interior materials - no kitchens → no restaurants - installation of warning systems - education and information of owners, employees, and fire department
Flood protection	The risk of flooding is almost unavoidable due to the direct proximity to the river but may be reducible through appropriate flood prevention measures and structural modifications to the surrounding river landscape.	- if possible: barriers and partitions along the river sections - water drains leading away from the warehouses flexible use of the ground floors, no storage of valuable objects in this area and acceptance of regular flooding

[21] PEARSON / KING 2000, p. 70.
[22]Maekawa / BELTRAN / HENRY 2015, p. 92.

Climate stability	- creation of a stable indoorenvironment - low fluctuation rate of temperature and humidity slow adaption of the inner climate to the outside climate and slow acclimatization of the buildingfabrics	- use of porous and hygroscopic building materials for hygrothermal buffering - controlled natural ventilation (balance between air tightness and defined ventilation openings) with caution to unwanted intake of cold or hot winds, pollutants, insects and driving rain [Maekawa*et al.*, 2015[23]]. no sealing of surfaces through paintlayers and protective coatings
Protection against waterand moisture intake	- protect buildings from water intake through rain, in-situ groundwater, and rainwater runoff	- replace the dense tar paving of the adjacent street with permeable pavingwith natural stones and permeable joints - perimeter foundation drains can limit groundwater intake from the roadside - closure of large openings that are susceptible to water ingress - installation and maintenance of water drainage systems (wall gutters, downspouts, wall projections and drip edges) maintenance of external walls, basement and roofs and closing of leaks
Prevention against biological infestation andpests	- complete exclusion of pests and biological infestation not possible,but: - reduce access possibilities - deny food sources - avoid conditions they prefer(warmth, water, and high humidity) - related to the protection againstwater and moisture intake and climate stability avoid building and interior fabrics that could be a food source	- keep temperatures below 20 °c - values less than 75% RH are recommended to avoid microbiologicalactivities[Maekawa*et al.*, 2002[24]]. - allow natural ventilation and air circulation - avoid building and interior fabrics that could be a food source (textiles, carpets,organic paint materials) - no storage of food / no restaurants - keep the surfaces clean and removedirt and dust regularly - Integrated Pest Management: → monitoring and control → appropriate education and support → Remedial action if damaging speciesare discovered low hazard or non-toxic methods ofcontrol[25].

[23]Maekawa / BELTRAN / HENRY 2015, p. 99-100.

Protect against extreme climate parameters and sudden fluctuations	- protection against heat and severe cold - avoid freeze-thaw events - avoid dew point temperatures and resulting condensation dimensional changes and the resulting mechanical stresses in objects, mainly caused by short term fluctuations should be avoided	- controlled conservation heating against condensation and freezing indoor temperatures - controlled air exchange - insulation with water vapor permeable, fire resistant ecological insulation materials (especially roof insulation, e.g., with natural fibres) condensation should be avoided by not letting warm and damp air into cooler rooms [Staniforth, S., 2007[26]].[9]
Ecological and financial sustainability	- use of electric devices on a low level - low maintenance reduction of the carbon footprint	- preference of passive, non-mechanical strategies of environmental control improvement of energy performance
Consideration of human comfort	For conservation approaches, it might be necessary to reduce the level of human comfort to improve the environmental conditions for the historic materials.	

Table 5 – most important aspects of preventive conservation

[FUTURE USE PROPOSALS AND CONCLUSION]

Use proposals

The past use is not applicable anymore, the following suggested uses are also not applicable to all warehouses but can be viewed as examples of multiple uses for a liveable district with consideration of the heritage value.

Proposals for new use considers the central location of the warehouses (in the city centre) and their recognized aesthetic value (also for tourists), but also the nature of the buildings which require periodic maintenance-interventions over time and their low ceiling heights associated with the lack of daylight indoors as limits to the possibilities of transforming warehouses to new use.

A) flea market where it's possible to buy handmade products and local craft-made objects and gadgets.

PRO	- exploitation of the site for daily / weekly / monthly events - bigger flux of tourists in the city

[24]Maekawa / Toledo 2002, p. 5.

[25]English Heritage Guideline for Integrated Pest management, in: https://www.english-heritage.org.uk/siteassets/home/learn/conservation/collections-advice--guidance/eh-guideline-for-insect-pest-management-ipm-in-eh-historic-properties---website-version.pdf, accessed on 03.06.2022.

[26]STANIFORTH 2007, p.7.

CON	- not suitable climate indoors during cold season (but climate is milder than outdoors) - impossibility to also sell food and edible gifts

b) temporary exposition (spoken workshop) where Trondheim university-students and national or international artists can show and discuss their final projects in this unique "exposition space".

PRO	- during warm season the location is similar to the one of the Venice Biennale - enlarged knowledge of Norwegian and foreign people about this built cultural heritage
CON	- not suitable climate indoors during cold season (but climate is milder than outdoors) - impossibility to expose every kind of artifacts (not heavy, not degradable, etc.)

c) offices and housing (residential private use) not a great solution, the identity of the place is lost.

PRO	- the human use (life inside the buildings) lasts all over the year - improvement of the aesthetic issue indoors and outdoors, maintenance for long time
CON	- modification to the original structure with loss of the original value - need of an optime thermal comfort inside the building (especially during cold season) - high risk of fire derived from domestic kitchen use

d) shops, restaurants (commercial / private use)not a great solution, the identity of the place is lost.

PRO	- the human use (life inside the buildings) lasts all over the year, although the paid access - improvement of the aesthetic issue indoors and outdoors, maintenance for long time
CON	- alteration of the original structure with loss of the original value - need of an optime thermal comfort inside the building (especially during cold season) - high risk of fire derived from professional kitchen use - high risk of biological colonization caused by the presence of raw food and ready meals

e) visitors' heritage site, the best solution for the preservation of the warehouses in their original state. They are presented as a museum site for architectural history, as a learning space that offers the possibility to get an idea of the authentic appearance of the city of Trondheim during its history. A walk through the building enriches the visitor thanks to the discovery of information about materials, craftsmanship and building techniques; traces of past; what was the use of the building elements; the results of deterioration due to the climate change (salt efflorescence) ... The visitor, in this way, becomes aware of the urgency of conservation interventions and sustainable lifestyle in any case.

PRO	- with public access, the human use (life inside the buildings) lasts all over the year - information given via audio guides and robust panels placed somewhere indoors - maximum authenticity and integrity, no changes of original substance and appearance - no heating and electricity necessary - authentic experience includes sense of "darkness"
CON	- not possible for all buildings, only one selected object could be treated like this - requirement of staff and maintenance (suggested public ownership for the public access)

The following Table summarizes all the previous aspects in relation to the choice criteria.

	flea market (local products)	temporary exposition (spoken workshop)	offices, housing	shops, pubs restaurants	visitors' heritage site
heritage interest management (preservation of authenticity, significance, historical value)	green	green	red	red	green
economic advantage (owner)	yellow	red	green	green	yellow
comfort of the visitors	yellow	yellow	green	green	yellow
accessibility for the public	green	green	red	yellow	green
similarity to the original use	yellow	red	red		yellow
improbability of fire	yellow	green	red		
occupation through the year (linked to the maintenance)	yellow	yellow	green	green	
applicability of the proposal (high = large scale DISTRICT low = small scale BUILDING)	yellow	yellow	yellow	yellow	yellow

Table 6: future use proposals in relation to the criteria of choice: high = green; medium = yellow; low = red.

[CONCLUSIONS]

Even if there are of course no warehouses from the founding time of Trondheim, a place like Bakklandet still can give people the opportunity to see how the city developed, what crises it went through and the foundational changes that affect it. In the past with the industrial revolution and in the present and unfortunately, the future with climate change.
The warehouses are obviously no longer used for their original purpose, because of the introduction of modern transportation and food refrigeration. But there could be a combination of offering groceries and other products.
It would serve the idea that even if you cannot use a Cultural Heritage Building in its old way, there is still a possibility of usage.

Beside the issue regarding conservation of the colour form location and bringing some utilization back, the conformity is also maybe important for the city.

At least one of them could also be used as a form of small exposition.

Since the warehouses were of big economic importance and they were also rebuilt, repaired, and renovated over and over again, they are of course in some way a window into the past.

A small exhibit, which would only use up one of those houses, could show people what the original purpose was. This small exhibit would be much smaller than an actual museum and maybe there would not even be the need for an entrance fee.
Old manufacturing tools and clothing, perhaps a model of an old fish boat, could be shown in combination with signs and audio guides.

Unlike many other small historical exhibits, it would also be an opportunity to display the direct and indirect impacts of climate change on these warehouses.

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