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# Factors to be considered in the design of indigenous communities' houses, with a focus on Australian first nation housing in the Northern Territory

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ABSTRACT

Housing in remote Australia's Indigenous communities has remained an unsolved challenge after many years of effort. Factors to be considered in remote housing have been researched broadly but rarely taking a holistic design point of view. This requires the inclusion of all factors that affect the success of a design project (eg resources, physical and social environment and processes). This study is a response to the question: which factors should engineers consider in their remote Indigenous communities building projects? In this study, these factors were extracted from a literature review. Special emphasis was put on resources related to the Northern Territory remote housing. Ten key factors which thus form goals for the establishment of any project were found after filtering and organising the findings from different publications. Experts in remote housing from the government, private sector and academia were then interviewed to gather their opinion on the solutions with respect to each factor. The results of this study will provide designers with a practical to-do list for planning and implementing their projects in remote communities. Further, the results could be used by decision-makers in developing policies.

## 1. Introduction

Housing in remote communities in Australia Northern Territory (NT) has remained a challenge and is still experiencing high cost, low quality of ongoing maintenance and relatively short building lifespan (Bailie and Wayte, 2006; Cant, O'Donnell, Sims and Harries, 2019; Fien and Charlesworth, 2012; Habibis et al., 2019; Lowell et al., 2018; Porter, 2009). The demand for additional houses in NT is high due to under-resourcing in this sector and rapid population growth. To meet the housing demand, at least 8000 to 12000 more dwellings are required (NTG, 2020). The scarcity of bedrooms in communities, leaving many to live with 20–30 people in a 3-bedroom house (Buergelt et al., 2017), leads to food scarcity in trying to share resources evenly between such a large group with conflicting needs; health issues from people sleeping on the floor with no room for separate beds; family violence due to the competition for limited resources and lack of privacy; disrupted schooling due to disturbances while studying at home, and more. While the occupants of the remote houses are largely blamed for the unhealthy living conditions or lack of ongoing maintenance, the policies implemented to construct and maintain remote housing have been found to be often sub-standard for many years (Altman, 2018; Altman et al., 2018; Lea and Pholeros, 2010; O'Rourke and Nash, 2019).

Conventionally, the evaluation of success in remote projects has been according to construction goals, i.e., the number of rooms built in a community per year (see Commonwealth of Australia, 2018). The objectives in the current Northern Territory Housing Strategy (NTG, 2020) include a range of goals such as flexibility, durability and local engagement in projects which suggests some improvement in remote housing policy in NT. That said, engineering solutions against these objectives are yet to be collated, developed, or verified.

A scoping literature review shows a lack of technical publications including engineering and design solutions for remote housing. Housing problems are mostly discussed from social, policymaking, and philosophical points of view and less from a practical engineering point of view. One reason could be the difficulty of prescribing solutions due to competing priorities in remote areas. For example, local engagement, local businesses, choice of construction technique, and training are all priorities (Fien and Charlesworth, 2012), and solutions that work for

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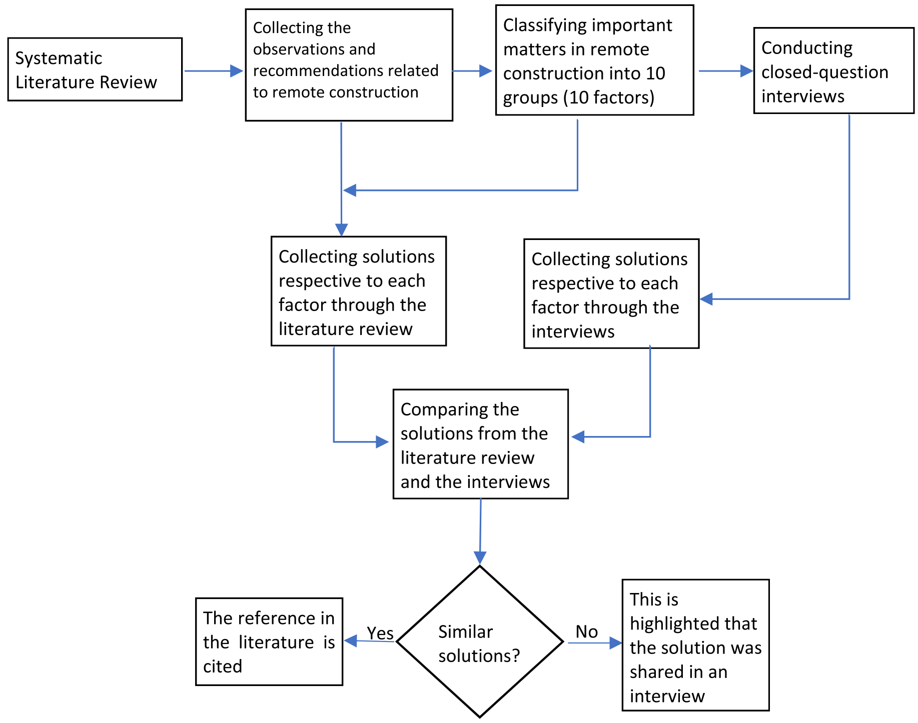


**Fig. 1.** Flowchart of the methodology of data collection, processing, and reporting.

one community might not work in another.

While the "*dessert syndrome*" (Stafford Smith, 2008) needs innovative solutions (Spencer et al., 2020), current design guidelines for remote construction, such as NTG compliance requirements, are well elaborated for architectural aspects of European house design, but not for remote housing. See, for example the Design Guidelines for Community Housing in NT (DIPL, 2019). After surveying academic and governmental literature sources, authors believe that current guidelines do not account for the housing design needs encountered in remote communities.

In this paper, factors that should be considered in remote housing projects as found in the existing literature have been collected and summarised. For each factor, design and engineering solutions are proposed. These factors apply broadly and are not specific to particular communities. Solutions have been collected through interviews with experts in remote NT housing. Existing literature on remote housing is reviewed from a design perspective to make an engineering interpretation of the points raised in the material collected.

## 2. Methodology

Firstly, a literature search covering over 100 research papers, technical reports and governmental documents was carried out, and important factors in the design and construction of remote houses in Australia were identified and collated. A scoping review of the available literature was conducted through a search for remote construction in Australia followed by requests to those involved in previous projects for any reports or documents produced. References used in this study covered a wide range of formats and were then categorised into the following groups.

1. Case studies reporting the experience and learned lessons from construction cases in different communities. These references were specific to a location but covered a range of factors.
2. Studies on one or a limited set of factors. Some references discussed the importance of one or a small set of factors in projects in different locations. So, this group of references covered a wide range of sites but a small number of factors.
3. References that were not on remote construction but discussed the factors mentioned in either group 1 or 2, so their findings were found related to the arguments in here.

After the literature review, the factors that were extracted as related to engineering and construction projects were filtered for frequency and allocated space in literature. This identified ten broad goals to be analysed in remote construction which are described as: community engagement; promoting intergenerational knowledge exchange; language protection; longevity and durability of the assets; retaining young people in the community; environmental integrity; cultural alignment; resilience against the effects of climate change; thermal comfort and flexibility.

Experts with significant experience in NT remote housing from the government, private sector, and/or academia were interviewed to share their solutions to address these goals. Authors managed to interview similar number of people from each sector, i.e. government, consultant companies, construction companies and academia. While specifically asked to share their solutions to the ten goals extracted from the literature, at the end of interviews, participants were asked to add any more factors beyond the discussed goals. Totally fourteen experts were interviewed in a closed-question format.

Most of the solutions presented here were proposed in the literature by people working on interstate projects. The application of solutions can be regionally dependant. If a solution was considered specific to a region or a community by the authors, the solution was discussed further with the interviewee to find the right context and scope for the solution to comply with the scope of the study, i.e., NT remote projects.

The key intention of the interviews was to expand on the material collected from the literature review and to verify if solutions are applicable to NT. Solutions shared by the interviewees were checked against those collected from the literature and if they were found similar, the references in the literature were cited alongside the interview results. When a new solution is proposed by an interviewee, this is stated clearly and differentiated from those existing in the literature. Interviewees were selected according to their experience with communities. In early meetings with people, the research group realised that people tend to share many interesting but irrelevant stories of their experience of working with communities. So, to make sure that the main research questions are answered, a closed questions format was selected for the interviews but at the end of the sessions the interviewees were given the opportunity to share any other relevant information. Answering the questions by the interviewees in many occasions led to telling stories to support their opinion.

These questions were asked in the interviews for every goal we had found:

1 By reviewing the literature, we have found (one of the goals we had found) is important to be considered in remote communities' construction. What do you think and can you share your experience of working on remote projects related to this goal.
2 What solutions do you have to meet this goal.
3 We have found (one of the solutions we had found) in the literature. Do you believe this solution is applicable in Australia's remote communities?

Then we asked:

Are there any other goals that you believe we need to consider? What solution/s can you suggest to addressing that goal.

The research group received an Ethics Approval coded H21010 by the CDU Human Ethics Committee to conduct the interviews.

The extracted goals were split up into two categories, goals across all housing phases and goals specific to planning and building design. Engineering and design solutions found from literature or interview are presented following each factor. Where any difference was found between the data sources, both views are provided. Even within the NT there is a wide range of climatic, social and financial conditions for construction which would need to be considered in choosing between options in practice. The significance of factors and the validity and effectiveness of solutions vary from one community to the other and thus are not discussed in this broad approach. After introducing each goal, a brief discussion about the goal or the associated solutions are presented. Fig. 1 shows the flowchart of the methodology of data collection and analysis.

As stated before, goals are presented in two groups: goals related to all phases of remote projects and those only associated with the design phase. The first group includes goals that have a broader scope and could include socioeconomic aspects. The second group, however, includes goals that are more specific to town planning and architectural design. Since the first group of goals have a larger scope, a wider range of solutions is associated with them. Thus, solutions to the first group of goals are split into engineering solutions and socioeconomic solutions. The source of solutions is stated when they stem from a publication or interviews. Authors' interpretations and discussions around solutions sometimes come with the original idea of the solutions coming from the literature or interviews.

## 3. Goals across whole housing phases (planning, design, construction, and maintenance)

This section considers goals suggested in the literature that could be followed in any phase of remote construction. These goals are distinguished from those which are specific to design phases which are discussed in the next section.

### 3.1. Community engagement in projects

For various reasons, community engagement in construction projects has been strongly supported in the literature. Community engagement is critical, at least for the following reasons: the importance of collaborative planning (Cox, 2014; Seemann and Marinova, 2010; Stewart et al., 2019); creating sustainable jobs for local people through community engagement in construction (DRD, 2016; Hay et al., 2017; Moran et al., 2008), the potential of training living skills and improving adult literacy and numeracy through engagement in practical tasks (Moran et al., 2008) and improving physical activities (Burgess et al., 2008; McDermott, O'Dea, Rowley, Knight and Burgess, 1998; Rowley et al., 2008). There are, however, significant challenges for effective community engagement in remote housing. For example, Community Land Tenure (Weiner and Glaskin, 2007), which gives the right of holding and occupying the land to the community, could be a barrier to individual house ownership and house ownership is a barrier to accessing community maintenance resources. Similarly, when managing rentals, the payments are often the responsibility of the head of the house, where they are dealing with a large number of people residing there and which puts a strain on the technology requiring maintenance (Memmott and McDougall, 2003). In this regard, a well-thought-out policy of a 'social landlord' system with face-to-face meetings and easier contact with the community would be significantly helpful (Spencer et al., 2020). Another challenge toward community engagement in relation to collaborative planning which some interviewees raised is that local people often desire houses in which they have seen other people (in cities) live. This makes the scope for alternative designs with relatively better engagement opportunities limited.

The following section proposes solutions to improve community engagement in remote housing projects from interviews with remote housing experts and research.

#### 3.1.1. Solutions to improve community engagement in projects

Community consultation is an important phase in community engagement and is part of normal construction procedure in the NTG Department of Infrastructure, Planning and Logistics (DIPL) (NTG, 2019), under which the Housing Reference Group conducts consultations with traditional owners and local people, and so gathers their views on desired architectural designs. Engaging the community effectively in the early phases of design, discussing alternative designs in enough detail and with enough elaboration, and engaging all people (especially Elders) in the design process could improve the acceptance of designs.

*3.1.1.1. Solution- engineering.* DIPL internal policies require building contractors to address a 42% community involvement requirement in projects. Solutions suggested by the experts surveyed in this study to improve local engagement in design include the application of BIM

(Building Information Modelling), AR (Augmented Reality) and VR (Virtual Reality) to communicate design with community people and receive their feedback in real-time. The local people could use BIM of the preliminary architectural design of remote houses connected with an AR/VR system to visualise the end product and capture their feedback. Amendments to the design could be done in real-time and updated designs could be fed into the system in the same community meeting. DIPL currently uses BIM to produce plastic 3D printed models of the houses shown to communities in the design phase.

Community engagement in remote projects could also be improved by applying concepts of Design for Manufacturing and Assembly (DfMA) in remote construction. Elements of a building could be designed in standard geometries and could be built or manufactured offsite. Local people then could be trained to assemble the elements. This could involve many easy-to-achieve skills, including measurement, matching, providing an audio version of the instruction, working with forklifts, etc. This training can be provided and community can continue to learn on the job when construction projects are running. All interviewees believed that simple life skills learned through practical involvement in real jobs could significantly help in improving the quality of life in communities and are generally more effective than conventional training in classes and workshops.

The interviewees also mentioned using local materials in construction to promote local engagement in construction projects. Indigenous people retain the knowledge of processing and implementing local materials from which remote construction could benefit, and their people would relate better to such materials in their houses. Traditionally fibre materials (Nash, 2000) such as spinifex (Powell et al., 2013) and termite mounds (Udoeyo et al., 2000) were used by Indigenous people previously and could be potentially used for western construction methods in remote areas. The majority of Interviewees expressed that using local materials in remote construction could enhance the sense of ownership, reduce the cost of materials, labour and shipment to remote areas and create jobs in remote communities.

An example of a potential local material is fibre-reinforced mudbrick. Indigenous people used different types of natural fibres for making tools, bindings for connecting building materials, containers and rafts (Gott, 2008; Miller, 2021). Research done at CDU in 2021 (GUO, 2021) found that if fibres of the right thickness and length are used in mudbrick, the strength and erosion resistance of bricks could exceed the minimum requirements needed for housing. Fig. 2 shows some samples made in this research. Indigenous use of spinifex in artefacts and the community stories around this technology encompass a large body of knowledge on selection, application and sourcing the right natural fibres for building applications.


**Fig. 2.** Mudbrick reinforced by Spinifex fibre which is wildly used by Indigenous people in tool making.

One important advantage of mudbrick is that it was used in mission days in some communities like Ali Curung. There is already at least one Aboriginal-owned mudbrick company in the NT and other constructions in sandbags and rammed earth in the Kimberleys. That means people in communities will already understand this technology and be able to work with it to discuss what they want in the design as they realise what is possible.

*3.1.1.2. Solutions - socioeconomic.* Social and cultural aspects of consultation in remote communities are crucial. Consultations with community and community organisations should include remuneration when dealing with elders and should extend to decision-making, as this impacts the broader well-being of the community (Christie and Campbell, 2013; Kutay et al., 2018). Further, consultation should be run along community divisions (Seemann et al., 2008) to ensure all parties are involved.

Community engagement in remote projects has a relatively short history, and not much known about the consequences of such engagements. Therefore, impacts or outcomes are not clear to us yet. For example, suppose community training is one of the engagement goals. Then imagine that training has been successful, and a fair number of community people involved in the project have gained a certificate and practical jobs during the project. So, altogether, the engagement looks successful with respect to training. A few months after completion of the project, trained people in the community realise that they no longer have a job because no new project has started, and they have the skill to earn more somewhere else. So, they decide to leave the community for better opportunities in the closest city. Soon they find themselves without work in the urban centres, away from home and drawn into severe alcohol and drug abuse. This story is close to real experiences. So, has the engagement been successful? Some other elements could be added to the engagement evaluation to consider the continuity of jobs for local people.

One would say being involved with too many western jobs would create cultural and generational gaps in communities. So, should communities be engaged in the projects at all? Many other possible scenarios could be imagined to show the uncertain future impacts of engagement in communities and, thus, the inaccuracy of any evaluation of engagement approaches. As well stated by (Rowe and Frewer, 2004) "*a clear definition of what it means for a participation exercise to be effective*" should be used to evaluate an engagement practice. This definition is not yet available in remote housing projects due to large cultural gaps between Indigenous and western cultures and the relatively short history of any such real engagement.

Another aspect of community engagement in remote projects that differentiates this kind of engagement from what is seen in health is the practical nature of the work. Common public participation methods have been developed for the policymaking phase but not the implementation phase. In remote housing projects, engagement is intended to extend to actual buildings with associated training. In this regard, engagement evaluation in remote housing might need to go beyond the criteria developed for common public participation. For example (Rowe and Frewer, 2000), lists the eight most formalised public participation methods: referenda, public hearing, public opinion survey, negotiated rule marking, consensus conference, citizen jury, public advisory committee and focus group. None of these eight methods go beyond decision-making and thus do not involve implementation as required in remote housing.

With all the complexities around developing such evaluation in remote housing, this is important to achieve, as we are hopeful that when doing the right things, it will be more likely to have the right impact. The experience of implementing engagement frameworks in local communities shows that having a right engagement process in place is essential in attaining the targeted outcomes (De Vente, Reed, Stringer, Valente and Newig, 2016). In particular "fairness and competency" (Webler and Tuler, 2000) are deemed umbrella criteria under which the whole process should be assessed.

Considering the complexity of engagement evaluation in remote projects, a free-goal evaluation approach, as discussed by (Chess, 2000), seems more suitable than user-based or theory-based methods. Regardless of the approach taken, some aspects seem essential to be considered in a plausible engagement evaluation framework. This includes reflection on community diversity (South et al., 2005), making a strong two-way learning channel (Altman et al., 2018; Kutay, 2021) and respect for the local culture of work in communities. The latter is of great importance in shaping any successful engagement. The Strategic Indigenous Housing Infrastructure Program (SIHIP) (Davidson et al., 2011; Jefferies et al., 2011; J Wigley, 2008) demonstrated how alliance contracting could incorporate social and economic targets and achieved a 33 per cent Indigenous workforce (at end 2010). To do this, the program identified how Aboriginal networks might best contribute to the procurement process. One program featured an Aboriginal person in the role of Alliance Workplace Coordinator with responsibility for managing the workforce. The labour pool was divided into self-selected groups of around four people, typically based on strong kinship ties. The group itself selected the leader of each group according to Aboriginal cultural values of appropriate status and leadership. This drew on internal positive outcomes of the engagement to ensure effective and cohesive teams.

Other measures include enabling community people to engage through sharing the language of building jobs; and enabling elders and young people to share this story. Working more with community stories or open discussion, rather than a directed question and answer session, allows the community to take control of the focus and content of the discussion. This allows for two-way learning as the community expresses their needs and priorities.

### 3.2. Promoting intergenerational knowledge exchange and community connectivity

Community engagement in construction can only occur when the community is able to discuss the process in which they wish to engage. While young community members may train and work onsite, this will be limited and not robust culturally and in the face of the values of their community, such as funerals and ceremonies, if there is not a strong community backing for their work.

#### 3.2.1. Solutions – social

While is becoming better understood the value of the wisdom of our Elders in Australia (MacCallum et al., 2010), this is already integral to Aboriginal community life. It will be difficult for youth to work against the wishes of their Elders, and it would be hard to engage the community in design or construction if the Elders are not behind the project. Implementing inclusive policies in construction and making construction sites similarly open to elders and younger members of communities could improve connectivity and thus, knowledge exchange between the generations in communities. Engaging Elders in construction and acknowledging their knowledge could be practically done by integrating 'Elders' knowledge of the region into the planning and design phases. Engaging elders in the early stage of planning and design makes knowledge of the local climate and terrain of the region available to decision-makers.

Porter (2009) considers a Recognition Space where the dual values of Aboriginal and mainstream society form a common space to negotiate tenancy and service management. This acknowledgement that mainstream values, biases and assumptions cannot be assumed in Aboriginal society is crucial for recognising the way forward with learning on both sides and knowledge sharing for mutual benefit.

### 3.3. Language protection

One aspect of Aboriginal culture considered fundamental to wellbeing is the retention and strengthening of language in the community (Angelo et al., 2019). This does not seem to be an issue in terms of construction, where the language for mainstream material and methods is lacking. However, suppose we wish for the community to be engaged in construction. In that case, they need to be able to talk about construction in a language that links this to the land, the climate, sustainability and cultural practices.

#### 3.3.1. Solutions- engineering

Stafford Smith (2008) talks about the need to develop training in the local language, which can be achieved more easily with training resources in Virtual or Augmented Reality. However, this is also a two-way process. Local people best understand the interdependencies, the feedback factors and the balance that can be achieved between variables in the community life, such as social responsibilities and work. Such a balance needs to be introduced into any construction program that is to have long-lasting value. Hence, one could see that the benefits of local engagement go beyond labour or transport costs. Engagement means participants can discuss and understand the project and the outcomes.

With this aim in mind, an avenue to protect local languages would be developing training materials in local languages. However, this is not feasible without local trainers who speak the language or by developing oral training resources online or in mixed reality settings. This way, the teaching material can be carefully interpreted for local people and presented alongside or instead of English instruction. This will enable VET, and HE graduates to speak the language of tradespeople and engineers and introduce the 'language of construction' into the community. Moreover, this will ensure that community consultation is well informed and provides viable designs for the local culture.

#### 3.3.2. Solutions- social

Another step towards enabling a community to speak the language of construction is mentoring students and local Aboriginal organisations. This should be included in the cost of a project to enable these people to have the opportunity to learn the tacit knowledge of construction and to practice their learning safely in a real environment (Christie and Campbell, 2013). As part of a two-way process, having local mentors for contractors included in their contracts to ensure they understand the environment they are working in makes considerable value. Results of interviews with builders show that the experience of working in remote communities can be quite isolating and has often left tradespeople unable to perform their duties up to the standard expected in Australian housing. This could be due to being paid before completing the job, they are unable to adjust to the many variations in customs and values in their new workplace, or they cannot adjusting their understanding of the Australian Standards to this new environment. Discussing these issues with someone versed in the ways of the other side of the culture interface will improve the ability to perform in remote locations (Hargrave, 1991).

### 3.4. Longevity and durability of the assets

In remote areas, structures have a relatively shorter life (Seemann et al., 2008), similar to people (AIHW, 2021). The service life of remote houses sometimes is as low as seven years, according to a remote housing project manager at the Department of Infrastructure Planning and Logistics (DIPL) of NTG. This is in agreement with the range of 4–8 years reported in (Mitchell et al., 2005). There are several reasons for the short lifespan of remote houses, including domestic violence attacks, and antisocial behaviours (Campo and Tayton, 2015; Stanley et al., 2003); harsh environment (Caitcheon et al., 2012; Sturman and Tapper, 1996); poor maintenance; and overcrowding (under-resourcing) (Bailie and Wayte, 2006; Buergelt et al., 2017; Melody et al., 2016). There are many factors associated with each of the above-mentioned reasons. For example, factors contributing to overcrowding include but are not limited to a different lifestyle, poor handyman skills and poor resource allocations. Discussion of these factors is out of the scope of this article. Instead, design and engineering contributions to durability is considered. Information presented below is largely adopted from interviews with the project managers and senior executive housing team at DIPL.

Causes for building deterioration in remote communities could be classified into environmental and social causes. Environmental causes encompass high humidity and extreme UV exposure, severe winds and cyclones, heavy rains, and flood. Social causes encompass poor technical skills, dependence on external service providers, domestic violence, etc. Two complementary approaches could be taken to improve buildings' durability in remote buildings, reducing external loads on the structures and making them more robust structures. Reducing external loads means reducing the chance of a building getting destroyed during domestic violence, and thus is more related to social causes. Many cases of dame in remote buildings are associated with vandalism and domestic violence. For example, if domestic violence decreases in a community, interior walls might not need to be as strong as they are commonly designed now. It is said that walls in remote houses should be able to withstand 'the axe test'.

#### 3.4.1. Solutions- social

Social effects could effectively be reduced by engaging the community in construction would improve the sense of ownership of the building between community people and reduce the chance of vandalism. The ability and desire of communities to maintain their assets are crucial to the long-term success of construction projects in remote areas (Moran et al., 2008). In this regard, basic engineering and vocational training could improve local people's ability to do fixing jobs, preventing major subsequent issues. Overcrowding sometimes happens due to a building being unfunctional, and thus residents need to move to a neighbour's house. Simple repair and replacement jobs that indeed need training could keep buildings functional for a longer time, reducing the chance of overcrowding.

#### 3.4.2. Solutions- engineering

Interviews with structural engineering consultants working on remote projects and also project coordinators at DIPL provided us with a list of solutions to improve the longevity of buildings in remote areas. These solutions include using masonry materials such as block work, extra wall reinforcement, avoiding steel frames, applying internal and external lining on walls, and reducing stud spacing if steel wall framing is used. Discussing the effectiveness and cost of these solutions is out of the scope of this article but must be considered in decision-making. Discussion with some community people has suggested that using Jali or perforated bricks to increase the exposure of what is occurring in houses could reduce the build-up of tension in a house and decrease violence.

As mentioned before, solutions to improve the robustness of the buildings and solutions to reduce social effects on the buildings are complementary to one another and should be considered as a package. Such work requires the setting up and funding of Aboriginal service organisations in each community or hub area. These are often linked to better communication over housing matters and more effective maintenance programs (Spencer et al., 2020).

Finally, the challenge of building longevity in remote could be seen from a different point and through the lens of the Indigenous lifestyle. In the indigenous lifestyle, temporality was an indispensable characteristic of accommodations. The culture of mobility and connection to mother nature led Indigenous people to minimise their demands of a building and set up their residence for a short stay between two trips. Temporality contrasts with concurrent lifestyle and design philosophies in which often a building service life is not less than 30 years. Surprisingly, in some communities that had the opportunity to keep the temporality concept alive, people faced fewer housing issues. An example is Manmoi in West Arnhem, where local people use temporary houses and replace light timber framing and roofs when they need them. Authors understand that this would not satisfy safety or serviceability requirements per Australian standards (AS1170 family of standards, for example); however, engineers should appreciate that none of these standards has been developed according to the Indigenous worldview.

### 3.5. Retaining young people in communities

Encouraging young people to keep their connection and support to the communities has been highlighted by (Moran et al., 2008). Upskilling young community people opens doors to new opportunities, and the sporadic nature of construction jobs in communities encourages them to leave their home community.

#### 3.5.1. Solutions- social

Whatever is gained is normally considered a shared asset in Indigenous communities. This is well aligned with the traditional Indigenous way of life. But, when an Indigenous young person works on a remote project, giving the wage away to others would discourage the person from staying with the community. The obligation to share a wage amongst family members has led to suggestions that community employment is done within the family groups. So, the duties can be shared between members. This means the matriarch, or patriarch, distributes the wages from any project, similarly to setting up a 'head tenant' in houses (Spencer et al., 2020).

Further, holding construction training in communities would encourage young members of communities to stay in their communities. With this said, the mobility of communities and the fact that the availability of community members would be different to what is called "business hours" should be appreciated in participative projects. A flexible work roster in which different trained community members could take over the job from one another could be a solution in this regard.

### 3.6. Environmental integrity and carbon emission reduction

Publications on remote housing stress the importance of sustainability in remote housing (Altman & May 2011; Fien et al., 2008a; Kestle et al., 2002). The sustainability of remote houses doesn't seem a major challenge at first glance when the population in remote areas is compared with the national population, i.e. less than 2% of the nation's population (AIHW, 2020). However, the significance of environmental integrity in building in remote communities becomes notable when one considers the rate of housing deterioration in remote areas (Mitchell et al., 2005; NTG, 2020; Seemann et al., 2008) and the importance of preservation of natural and cultural sites in these areas (NTG, 2020).

#### 3.6.1. Solutions- engineering

To improve the sustainability of remote houses, the interviewees shared the following solutions: using solar energy, utilising reusable modular construction elements, making local solar farms rather than individual solar energy systems, using renewable energy in transport, using hydrogen for restoring solar energy and monitoring the market for new passive solar techniques, reducing the dependence of the diesel power generators commonly used in remote communities, reducing heat transfer onto external walls and roof and into the house, and enhancing flexibility in the structure so future alteration could be accommodated with the current design. The latter would significantly reduce material waste in remote areas, given the varying size of households in most remote communities.

The interviewees also mentioned that steel frame construction with internal mesh to support a "wattle and daub" style construction using local materials such as clay and spinifex as an alternative to directly building with mudbrick. Weather effects could be noticeable in this system, but this method of construction allows the community to recover the material and rebuild.

Sustainability could also be improved by providing and maintaining equipment such as overhead fans as part of the house built to ensure reduced reliance on air conditioning and the use of verandas and high ceilings. Finally, offering general training to communities on effective maintenance could improve the durability of remote houses (see 3.3) and reduce the amount of waste deposal in remote areas. This could be done by aggregating the provision of services across communities (Robertson, 2018; Seemann et al., 2008).

## 4. Goals specific to planning and building design

During the literature survey, several goals were identified as directly related to the building design. This section discusses these goals and solutions shared by the interviewees in this study.

### *4.1. Culturally aligned design*

There are many approaches to providing suitable designs for remote communities from the literature. While the focus is on the construction constraints, these relate closely to work by (Fien et al., 2007), who isolated two principles through consultation:

1. Principles of sustainability for remote Indigenous housing
2. The application of these principles at key decision points in the housing system.

In fact, sustainability is fundamental to Aboriginal life, which is commonly neglected in the concurrent design process, which makes us rely on constant consultation and engagement to ensure sustainability is integrated into any construction. Also, the work of (Memmott, 2003) is referred to where he proposed decentralising the essential components of a house. This allows different spaces of remote architecture to be developed over time independently. This process starts by considering the natural subdivision of housing space into areas such as night and day, dry and wet areas, cold and hot spaces, and gender-specific needs. These separate designs combine to form a house but in a more time and space unified way. The location of families and family members in relation to each other should be considered in the separation of spaces. This is to reduce problems with avoidance requirements and family disputes. Further, the design should consider the placement of elders away from 'humbug' and noise but near carers, if needed. That is when even the role of a single house in a community needs to be considered.

Moreover, the work by Memmott (1991) presents a list of 37 criteria for architectural design criteria at Wilcannia. Some of these criteria seem to apply to most remote Indigenous communities. These include:

- Sociospatial divisions to generate residential precincts.
- Accessibility to the domiciles from several directions supports pedestrian movements between the residences.
- Maximising outdoor living area including a shaded hearth which is useable in summer.
- Maximising audio-visual communication between some neighbours and minimising that between some other neighbours according to the social norms.
- A large enough gathering and cooking space inside.
- Most rooms should be multifunctional to accommodate sleeping, eating, social interaction, etc.
- For the more independent household segment, sleeping rooms should be cable opening to the outdoor, while nuclear families' sleeping rooms should be interlinked.
- Considering a "deep room", which is a more quiet and less accessible room as a sleeping space for the elderly.
- Consistency in room size and length/width aspect ratio.
- Maximising visibility of outside from inside while maintaining privacy in sleeping areas.
- Providing territorial markers but not necessarily fence around the domiciliary space.

Design around a central open or covered cooking area as closer to traditional food preparation methods is preferred in remote communities (Grant et al., 2018; J Wigley and Wigley, 1990). Traditionally, cooking in communities was done at the hunting location, and the waste was left to decompose back into the landscape. An open cooking area will reduce odours and food waste problems within the house walls, allow for the variable size of the eating group and reduce smoke, grease and vermin damage to cupboards in any remaining kitchen area. It will also reduce the need for cooling space, where long, slow, or repeated hot cooking occurs (Grant et al., 2018; J Wigley and Wigley, 1990). In general, an open living plan with suitable shade, which reduces heat and protects residents from rain, is more consistent with Indigenous people's lifestyle (Page et al., 2021).

Internal walls such as those in toilet areas and bedrooms in remote houses should be designed to provide privacy. Preferably walls should be open to the breeze at a suitable location (e.g. exterior walls to communal areas and not bedrooms). This is seen as a benefit for reducing heat. Further, this also increases the visibility of family disputes to those around to reduce the escalation of violence.

Moreover, religious beliefs and Indigenous spirituality (Basedow, 1925) could be integrated into architectural design. Considering this factor could make substantial changes in the current designs. For example (Keys, 1999) explains the Walpiri people consider that they sleep better in houses with a north-south alignment. This is counter to standard architectural wisdom in Australia. However, this matchs the alignment of magnetic termite mounds, which is known to provide thermal regulation in local solar and wind conditions (Fagundes et al., 2020). Further, walls and roofs could include design options based on totemic symbols to encourage a relationship between residents and the house (Page et al., 2021).

Finally, as a word of caution in any remote housing project, the words of (Go-Sam, 2008) are quoted here:

> "Many Aboriginal clients may resent any housing that deviates from the local white standards of rural or urban housing. Behind this reaction is the understandable desire to achieve equality, to be accepted, to have some modest but recognised status and not to be ridiculed."

The reality on the ground is that remote communities are well impacted by western design and lifestyle. A reasonable framework for housing design would emphasise the possibilities of what might be achieved if communities are allowed to take control of their housing design, with the skills to understand and adapt modern materials and processes. This already exists with the building of temporary or reused mortuary camps for the family of a recently deceased person and the town camps constructed around rural townships.

### *4.2. Resilience against the effect of climate change*

Climate change has increased the chance of severe floods and bush fires in remote communities (Green et al., 2009; Green and Minchin, 2014; Hall and Crosby, 2020). Another aspect is the bore water that is often the supply to the community and is often highly corrosive to metal due to its high salt content (Rajapakse et al., 2019; Russell and Ens, 2020). Climate change would diminish bore water quality in remote communities, which would have adverse health effects. This would also reduce the water utilities' longevity and hence increase the housing supply cost.

Given the difficulty in accessing remote communities and immediate provision of recovery solutions after a disaster, considering a larger safety factor in design for fire and flood was deemed reasonable by all

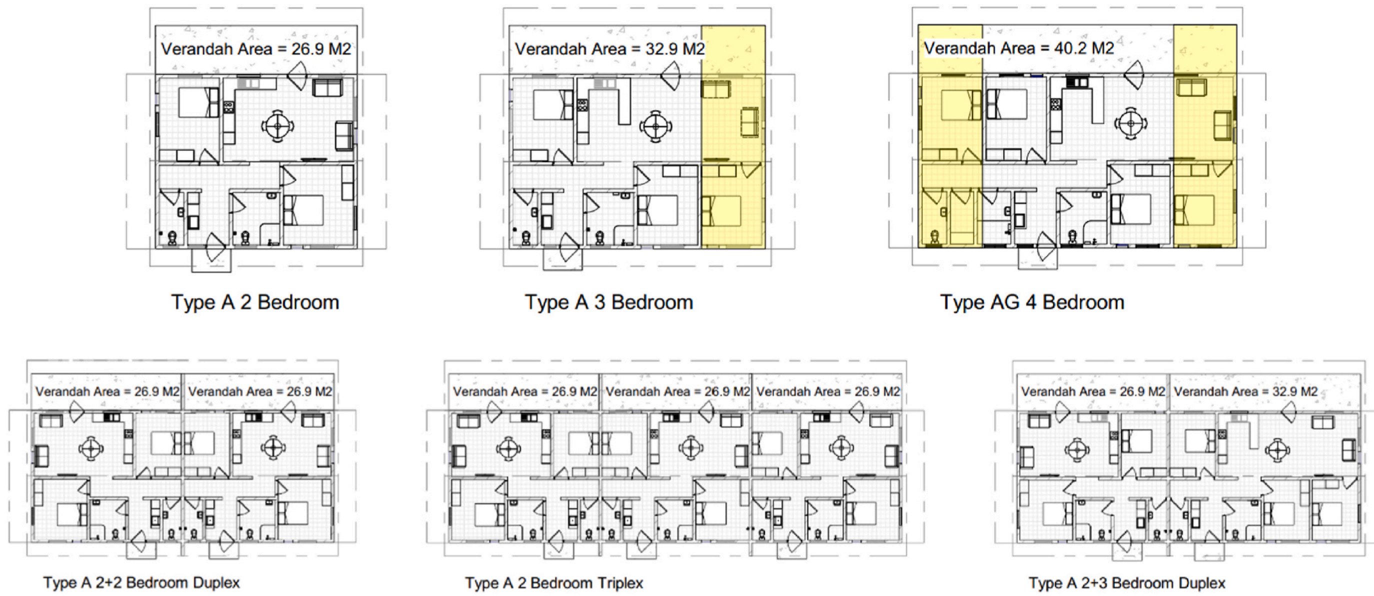


**Fig. 3.** An example of a modular plan used by DIPL. The plan has the capacity to be updated into a four- or five-bedroom house in future. Drawings courtesy of Northern Territory Government, Department of Infrastructure, Planning and Logistics.

interviewees in this research. Solutions offered in this regard included considering a flood level higher than that in non-remote areas, reducing communities' dependence on groundwater, applying fire-rated cladding, improving external and internal wall insulations and using elevated building designs in flooding regions. It is worth mentioning that DIPL currently considers a 300 mm safety margin above the flood level recommended by the standard in remote buildings design.

### 4.3. Thermal comfort and energy efficiency (reducing cost of energy)

Thermal comfort, which is greatly related to energy costs in remote areas, has been well discussed in the literature on remote housing (Altman, 2018; Altman & May 2011; Burroughs, 2013; Fien et al., 2008b; O'Rourke and Nash, 2019). Heat waves, limited shading and significant temperature difference between day and night in NT remote areas highlight the importance of a well-thought thermal design of residences.

The interviewees suggested the following solutions improve the thermal comfort of buildings in remote areas: considering large eaves and airways in the plan, reducing widows' size on the north side of the building, orienting windows facing the wind ward, considering veranda on the north side, using cool room type of materials for external walls and ceiling when possible. Evaporate cooling was found to be relatively expensive and short in-service time. Further, reducing dependence on electrical cooling systems was emphasised to reduce the demand for deploying electricians to remote areas to fix simple issues. The use of verandas has been common in Australian Architecture to reduce heating in the house. However, communities tend to brick in verandas to make extra rooms due to the low space and under-resourcing in housing (Go-Sam, 2008). An alternative would be using Jalis or perforated bricks made from mud or cement around the house to reduce heating on external walls.

### 4.4. Flexibility

Flexibility refers to the opportunity to alter remote houses if changes are needed in the future. Ritual and cultural events, moving culture in some communities (Zufferey and Chung, 2015), under sourcing, and short lifespan (Mitchell et al., 2005; Seemann et al., 2008) of buildings could extend the demand for a simple family dwelling to accommodation for extended family. Varying demand for remote houses which are sometimes vacant due to permanent or seasonal migration of indigenous people (Davies and Quicke, 2021; Gray, 1989; Prout, 2018) and sometimes host more than 30 people (Bailie and Wayte, 2006) is a good reason for considering flexibility in remote houses.

Some solutions have been proposed in the literature or reached after many practical tries and adjustments in remote housing to improve flexibility (O'Rourke and Nash, 2019). express the importance of yards and domestic landscapes in remote houses as reserved spaces for family functions, outdoor activities, and future alterations. Shaded open spaces, which are well respected in Indigenous architecture (Page et al., 2021) could also improve the flexibility of the remote houses by easing the limitations that block, or steel frame walls create for living spaces. Flexibility could be improved by applying modular design so that extra rooms can be attached to existing houses in a straightforward process (see 4.4). Further, a living pod that lets more families live nearby without having too many people in one house could improve the flexibility of the living area (Christie and Campbell, 2013). Moreover, flexibility and thus sustainability could also be improved through panelised construction with an easy lock system. In such a system, the house can be dismantled and used for a rebuild, e.g. after a death or breakage of part of the house. However, this form of construction was not found to be robust in the cases of severe winds, according to the project managers at DIPL. This needs to be followed up to clarify the cause of failure.

(Slaughter, 2001) A study on 48 residential, commercial, and industrial buildings in the US identified ten key strategies to improve flexibility in buildings. According to this study, flexibility improvement strategies ultimately added 2% extra construction costs to the projects. Some of the strategies discussed in (Slaughter, 2001) and seem applicable to remote housing are as follows:

- Reducing inter and intra-system interactions

A system or part of a system could be replaced without significant interference in other systems or elements. An example is a prefabricated modular cladding in which a part could be replaced without disturbing the whole cladding. Another example is a panelised wall which allows changing the doorway's location by rearranging the panels.

- *Predictability*

**Table 1**
Summary of factors collected in this study and respective solutions.

| Phase in which factor should be considered | Factors to be considered | Solutions collected in this study | References |
|---|---|---|---|
| Goals across whole housing phases | Community engagement in projects | Community consultation in the early stage of the design, engaging elders, Design for Manufacturing and Assembly (DfMA), Use of local materials in construction, emphasising a fair and competent process for local engagement rather than too much focus on outcomes, a free-goal evaluation approach for assessing local engagement. | (Burgess et al., 2008; Christie and Campbell, 2013; Cox, 2014; DRD, 2016; Hay et al., 2017; Kutay et al., 2018; McDermott et al., 1998; Memmott and McDougall, 2003; Moran et al., 2008; NTG, 2019; Rowley et al., 2008; Seemann and Marinova, 2010; Seemann et al., 2008; Spencer et al., 2020; Stewart et al., 2019) |
| | Longevity and durability of buildings | Reducing domestic violence by engaging the community in construction, engineering and vocational training, culturally acceptable designs, accessibility and affordability of repair resources, reducing delays in maintenance jobs, better allocations and logistics of resources, using masonry materials, extra reinforcement of walls, avoid using steel frames, applying internal and external lining on walls, and reducing stud spacing if steel wall framing is used, adopting temporality concept from Indigenous worldview if possible. | (AIHW, 2021; Seemann et al. (2008); Mitchell et al. (2005); ( Caitcheon et al. (2012); Sturman and Tapper (1996); Bailie and Wayte (2006); Buergelt et al. (2017); Melody et al. (2016); ( Page et al., 2021; Christie and Campbell, 2013; Robertson, 2018; Spencer et al., 2020) |
| | Retaining young people in communities | Share a wage amongst family members, share duties between family members, hold construction pieces of training within communities and have a flexible work roster. | (Moran et al., 2008; Spencer et al., 2020). |
| | Language protection | Developing oral training materials in local languages, involving local trainers who speak the language. | (Angelo et al., 2019; Stafford Smith (2008) Christie and Campbell, 2013) |
| | Environmental integrity and carbon emission reduction | Using solar energy, utilising reusable modular construction elements, making local solar farms rather than individual solar energy systems, using renewable energy in transport, using hydrogen for restoring solar energy, monitoring the market for new insulation solutions, reducing heat transfer from external walls and roof, and enhancing flexibility in the structure, wattle and daub, reduced reliance on air conditioning, offering general training to a local cluster of communities on effective maintenance. | (Altman & May 2011; Fien et al., 2008a; Kestle et al., 2002; AIHW, 2020; Mitchell et al., 2005; NTG, 2020; Seemann et al., 2008; Robertson, 2018; Seemann et al., 2008) |
| Goals specific to planning and building design | Culturally aligned design | Integrating sustainability in designs, decentralising the essential components of a house, placement of elders away from the noise but near carers, design around a central open or covered cooking area, walls should be open to the breeze, increasing visibility of family disputes, integrating religious beliefs and Indigenous spirituality in the design in terms of room alignment, totemic design, etc. | (Fien et al., 2007; Memmott, 2003; Grant et al., 2018; J Wigley and Wigley, 1990; Grant et al., 2018; J Wigley and Wigley, 1990; Page et al., 2021; Basedow, 1925; Keys, 1999; Fagundes et al., 2020; Go-Sam, 2008) |
| | Resilience against the effect of climate change | considering a larger safety factor in design for fire and flood effects, considering a flood level higher than that in non-remote areas, reducing the dependence of communities on groundwater, applying fire-rated cladding, and improving external and internal wall insulations and using elevated building designs in flooding regions. | (Green et al., 2009; Green and Minchin, 2014; Hall and Crosby, 2020; Rajapakse et al., 2019; Russell and Ens, 2020). |
| | Thermal comfort and energy efficiency | considering large eaves, airways in the plan, reducing windows' size on the north side of the building*, orienting windows facing windward, considering veranda on the north side*, using cool room type | (Altman, 2018; Altman & May 2011; Burroughs, 2013; Fien et al., 2008b; O'Rourke and Nash, 2019; Go-Sam, 2008) |

(continued on next page)

Table 1 (*continued*)

| Phase in which factor should be considered | Factors to be considered | Solutions collected in this study | References |
|---|---|---|---|
| | | of materials for external walls and ceiling when possible, reducing dependence on electrical cooling systems, reduce the demand on deploying electricians to remote areas, use of Jali. * Note that Australia is in Southern Hemisphere | |
| | Flexibility | Including yards and domestic landscapes, shaded open spaces, reducing inter and intra-system interactions, Improving physical access, oversize eaves and slabs, and employing offsite modular construction. | (Zufferey and Chung, 2015; Mitchell et al., 2005; Seemann et al., 2008; Davies and Quicke, 2021; Gray, 1989; Prout, 2018; Bailie and Wayte, 2006; O'Rourke and Nash, 2019; Page et al., 2021; Slaughter, 2001; TFHC, 2019) |

An example is running utilities at specific locations (at the columns, for instance) and keeping this as a convention in all buildings in the community and making this convention clear in the drawings so in future people be certain about where utility lines are.

- *Improving physical access*

An example is panelised cladding which makes it easy to access wirings without damaging the walls.

- *Phased installation/construction and simplified demolition*

Possible future alterations, including additions or demolitions, could be predicted and reflected in the design and construction.

An example of phased construction is the modular building plans used by DIPL in their recent developments. Modular plans allow the future annexation of new rooms with minimal changes in roof boundaries (see Fig. 3).

Oversized eaves and slabs could also generate shaded outdoor spaces for current use and be turned into new rooms for future needs. Large verandah space is now a common feature in all 30 standard design variants that DIPL uses in remote housing.

Flexibility could also be improved by employing offsite modular construction such as Prefinished Prefabricated Volumetric Construction (PPVC). Unless community people do offsite jobs in a construction and training hub, PPVC would not have much potential to engage local people in housing. The decision-makers need to find the right balance in the trade-off between flexibility and community engagement in this regard. While improving building flexibility is normally inexpensive (Slaughter, 2001), it could significantly improve the efficiency of programs like Room to Breathe (TFHC, 2019).

## 6 An overview of the results

In previous sections, factors that should be considered in remote housing projects were discussed. These factors were found in the existing literature. For each factor, design and engineering solutions were proposed. Factors explained in previous sections are listed, and related solutions are summarised in Table 1.

## 5. Discussion and recommendation for future studies

Factors discussed in the paper could be employed to develop an evaluation framework for remote housing projects. Success of remote housing projects commonly is evaluated according to the number of rooms built. While number of needed rooms in remote communities would be a reasonable indicator of severity of overcrowding, low number of needed rooms would not be an indicator of the success. There are several factors to be considered in engineering domain of actions for remote housing and therefore success in a remote construction project seems to be multi-dimensional index. For example, a successful remote housing project is expected to engage local people in an effective and sustainable way in construction, to help in developing local skills in maintaining the building, to involve elders in planning stage, to produce a long-lasting home, etc. Methods for measuring these factors need thorough studies. Further, importance of factors could be significantly different from one community to the other.

A major challenge for measuring the success according to the discussed factors would be interconnection or dependence of these factors. As such, by addressing one factor other factors could be improved and otherwise. For example, physical activities and intergenerational knowledge exchange could both be improved by local employment. Quality of interaction between goals were not studied in here and could vary from one community to another. Further, prioritising the factors and associated solutions should be studied for different communities individually and according to their existing resources such as skills available in the community, labour, local materials, etc.

Reflection of some factors discussed in here could also be found between the objectives of NT housing strategy (NTG, 2020) which is a promising sing that research resources are being consulted in developing NT housing strategy. These objectives are as follows:

- Create a housing and homelessness system that is contemporary, flexible and accessible
- Improve the long-term sustainability of the housing system in the NT.
- Provide appropriate housing aligned to the needs and aspirations of households andcommunities.
- Strengthen access for Territorians to a range of housing options, including social and affordable housing, private rental, and home ownership.

Between the factors discussed in this paper flexibility, sustainability and longevity are mentioned in the objectives of NT housing strategy which is a positive sign of learning lessons from previous attempts. Diffusion of these objectives into the engineering solutions should be documented and become available to the technical community.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

## References

Profile of Indigenous Australians, 2020. AIHW (Retrieved from).
AIHW, 2021. Rural & Remote Health. Australia Australian Government, Australian Institute of Health and Welfarte.

Altman, J., 2018. Alleviating poverty in remote Indigenous Australia: The role of the hybrid economy.

Altman, J., Biddle, N., Hunter, B., 2018. The challenge of'closing the gaps' in Indigenous socioeconomic outcomes.

Altman, J., May, K., 2011. Poverty alleviation in remote Indigenous Australia. In: First World, First Nations: Internal Colonialism and Indigenous Self-Determination in Northern Europe and Australia. Sussex Academic Press.

Angelo, D., O'Shannessy, C., Simpson, J., Kral, I., Smith, H., Browne, E., 2019. Well-being and Indigenous Language Ecologies (WILE): a Strengths-Based Approach: Literature Review. National Indigenous Languages Report. Pillar 2.

Bailie, R.S., Wayte, K.J., 2006. Housing and health in Indigenous communities: key issues for housing and health improvement in remote Aboriginal and Torres Strait Islander communities. Aust. J. Rural Health 14 (5), 178–183.

Basedow, H., 1925. *The Australian Aboriginal*: Adelaide. FW Preece.

Buergelt, P.T., Maypilama, E.L., McPhee, J., Dhurrkay, G., Nirrpuranydji, S., Mänydjurrpuy, S., Moss, S., 2017. Housing and overcrowding in remote indigenous communities: impacts and solutions from a holistic perspective. Energy Proc. 121, 270–277.

Burgess, P., Bailie, R., Mileran, A., 2008. Beyond the mainstream: health gains in remote Aboriginal communities. Aust. Fam. Physician 37 (12), 986.

Burroughs, S., 2013. Post-construction review of sustainable housing for indigenous people in the remote community of nguiu. AUSTRALIA.

Caitcheon, G.G., Olley, J.M., Pantus, F., Hancock, G., Leslie, C., 2012. The dominant erosion processes supplying fine sediment to three major rivers in tropical Australia, the Daly (NT), Mitchell (Qld) and Flinders (Qld) Rivers. Geomorphology 151, 188–195.

Campo, M., Tayton, S., 2015. Domestic and Family Violence in Regional, Rural and Remote Communities. Australian Institute of Family Studies.

Cant, R.L., O'Donnell, M., Sims, S., Harries, M., 2019. Overcrowded housing: one of a constellation of vulnerabilities for child sexual abuse. Child Abuse Negl. 93, 239–248.

Chess, C., 2000. Evaluating environmental public participation: methodological questions. J. Environ. Plann. Manag. 43 (6), 769–784.

Christie, M., Campbell, M., 2013. Consultations for Better Housing Outcomes.

Commonwealth of Australia, D. o. t. P. M. a. C, 2018. Remote Housing Review: A Review of the National Partnership Agreement on Remote Indigenous Housing and the Remote Housing Strategy, pp. 2008–2018 (Retrieved from).

Cox, E., 2014. Work with Us Not for 'us' to End the Indigenous Policy 'chaos. The Conversation.

Davidson, J., Memmott, P., Go-Sam, C., Grant, E., 2011. Remote Indigenous Housing Procurement: a Comparative Study.

Davies, A., Quicke, S.P., 2021. Population mobility ''', 'usual 'residence'and the census: the case of ' 'Australia's grey nomads. Australian Population Studies 5 (1), 9–17.

De Vente, J., Reed, M.S., Stringer, L.C., Valente, S., Newig, J., 2016. How does the context and design of participatory decision making processes affect their outcomes? Evidence from sustainable land management in global drylands. Ecol. Soc. 21 (2).

DIPL, 2019. *Design Guidelines Community Housing* NT. DIPL.

DRD, 2016. Resilient Families, Strong Communities: a Roadmap for Regional and Remote Aboriginal Communities. Regional Services Reform Unit (Retrieved from).

Fagundes, T.M., Ordonez, J.C., Yaghoobian, N., 2020. The north–south orientation of Australian termite mounds is due to the Sun and local wind: a heat transfer investigation. J. Appl. Phys. 128 (8), 084903.

Fien, J., Charlesworth, E., 2012. 'Why 'isn't it solved?': factors affecting improvements in housing outcomes in remote Indigenous communities in Australia. Habitat Int. 36 (1), 20–25. https://doi.org/10.1016/j.habitatint.2011.05.002.

Fien, J., Charlesworth, E., Lee, G., Morris, D., Baker, D., Grice, T., 2007. Flexible Guidelines for the Design of Remote Indigenous Community Housing, vol. 98. Australian Housing and Urban Research Institute Positioning Paper Series, pp. 1–65.

Fien, J., Charlesworth, E., Lee, G., Morris, D., Baker, D., Grice, T., 2008a. ToJ. Australian Popul. Assoc.wards a design framework for remote Indigenous housing. AHURI Final Report 114, 1–110.

Fien, J., Charlesworth, E., Lee, G., Morris, D., Baker, D.C., Grice, T., 2008b. A New Design Framework for Remote Indigenous Housing, vol. 101. Research & Policy Bulletin.

Go-Sam, C., 2008. Working with and against Indigenous design paradigms. Architect. Aust. 97 (5).

Gott, B., 2008. Indigenous use of plants in south-eastern Australia. Telopea 12 (2), 215–226.

Grant, E., Greenop, K., Refiti, A.L., Glenn, D.J., 2018. The Handbook of Contemporary Indigenous Architecture. Springer.

Gray, A., 1989. Aboriginal migration to the cities. Journal of the Australian Population Association 6 (2), 122–144.

Green, D., Jackson, S., Morrison, J., 2009. Risks from Climate Change to Indigenous Communities in the Tropical North of Australia. Department of Climate Change, Commonwealth of Australia.

Green, D., Minchin, L., 2014. Living on climate-changed country: indigenous health, well-being and climate change in remote Australian communities. EcoHealth 11 (2), 263–272.

Guo, D., 2021. *Non-fired Clay Brick for Remote Housing In Northern Territory.* (Master). Charles Darwin University Darwin, Australia.

Habibis, D., Phillips, R., Phibbs, P., 2019. Housing policy in remote Indigenous communities: how politics obstructs good policy. Hous. Stud. 34 (2), 252–271.

Hall, N.L., Crosby, L., 2020. Climate change impacts on health in remote indigenous communities in Australia. Int. J. Environ. Health Res. 1–16.

Hargrave, S., 1991. *Whitefella Culture*: Summer Institute of Linguistics. Australian Aborigines and Islanders Branch.

Hay, A., Zuo, J., Han, S., Zillante, G., 2017. Lessons Learned from Managing a Remote Construction Project in Australia. Paper presented at the Proceedings of the 20th International Symposium on Advancement of Construction Management and Real Estate.

Jefferies, M., Schubert, A., Awad, R., 2011. A Project Alliance Approach for the Procurement of Indigenous Social Housing in Australia. Paper presented at the RICS Construction and Property Conference.

Kestle, L., London, K., Bodger, P., Storey, B., 2002. The Development of a Typology for Remote Construction Projects. Paper presented at the Proceedings of the 18 th ARCOM Annual Conference.

Keys, C.A., 1999. The architectural implications of Warlpiri Jilimi.

Kutay, C., 2021. Knowledge elicitation with aboriginal Australian communities. Australasian J. Inform. Syst. 25.

Kutay, C., Gunay, B., Tobin, C., 2018. Cross-cultural Construction Engineering with Aboriginal Communities. Australasian Association of Engineering Education.

Lea, T., Pholeros, P., 2010. This is not a pipe: the treacheries of indigenous housing. Publ. Cult. 22 (1), 187–209.

Lowell, A., Maypilama, Ḻ., Fasoli, L., Guyula, Y., Guyula, A., Yunupiŋu, M., Garrutju, J., 2018. The 'invisible 'homeless'–challenges faced by families bringing up their children in a remote Australian Aboriginal community. BMC Publ. Health 18 (1), 1–14.

MacCallum, J., Palmer, D., Wright, P., Cumming-Potvin, W., Brooker, M., Tero, C., 2010. Australian perspectives: community building through intergenerational exchange programs. J. Intergener. Relat. 8 (2), 113–127.

McDermott, R., O'Dea, K., Rowley, K., Knight, S., Burgess, P., 1998. Beneficial impact of the Homelands Movement on health outcomes in central Australian Aborigines. Aust. N. Z. J. Publ. Health 22 (6), 653–658.

Melody, S., Bennett, E., Clifford, H., Johnston, F., Shepherd, C., Alach, Z., Zosky, G., 2016. A cross-sectional survey of environmental health in remote Aboriginal communities in Western Australia. Int. J. Environ. Health Res. 26 (5–6), 525–535.

Memmott, P., 1991. Humpy, house and tin shed-Aboriginal settlement history on the Darling River.

Memmott, P., 2003. Housing Design in Indigenous Australia. Royal Australian Institute of Architects.

Memmott, P., McDougall, S., 2003. Holding Title and Managing Land in Cape York: Indigenous Land Management and Native Title.

Miller, E., 2021. Finding Fibre in the Rock Art and Ethnography of Western Arnhem Land, Northern Australia, vol. 38. Australian Rock Art Research Association.

Mitchell, J., Pearce, R., Stevens, M., Taylor, J., Warchivker, I., 2005. Indigenous Populations and Resource Flows in Central Australia: A Social and Economic Baseline Profile. Centre for Remote Health: Alice Springs, NT.

Moran, M., Wright, A., Renehan, P., Szava, A., Beard, N., Rich, E., 2008. *The Transformation of Assets for Sustainable Livelihoods in a Remote Aboriginal Settlement*: Desert Knowledge. CRC.

Nash, D., 2000. Aboriginal Plant Use and Technology. Australian National Botanic Gardens. ACT, Australia.

Everyone Together 2019–2029. Northern Territory Government Aboriginal Affairs Strategy, 2019. NTG. NTG Retrieved from. https://dcm.nt.gov.au/_data/assets/pdf_file/0010/799219/everyone-together-aa-strategy.pdf.

A Home for All Territorians, Northen Territory Housing Strategy: 2020 - 2025, 2020. NTG (Retrieved from Northern Territory of Australia).

O'Rourke, T., Nash, D., 2019. Aboriginal yards in remote Australia: adapting landscapes for indigenous housing. Landsc. Urban Plann. 182, 124–132. https://doi.org/10.1016/j.landurbplan.2018.10.013.

Page, A., Memmott, P., Neale, M., 2021. Design: Building on Country. Thames & Hudson Australia Pty Limited.

Porter, R., 2009. Towards a Hybrid Model of Public Housing in Northern Territory Remote Aboriginal Communities? Citeseer.

Powell, O., Fensham, R.J., Memmott, P., 2013. Indigenous use of spinifex resin for hafting in north-eastern Australia. Econ. Bot. 67 (3), 210–224. https://doi.org/10.1007/s12231-013-9238-3.

Prout, S., 2018. *On The Move? Indigenous Temporary Mobility Practices in Australia*: Canberra, ACT. Centre for Aboriginal Economic Policy Research (CAEPR) (The).

Rajapakse, J., Rainer-Smith, S., Millar, G.J., Grace, P., Hutton, A., Hoy, W., Hudson, B., 2019. Unsafe drinking water quality in remote Western Australian Aboriginal communities. Geogr. Res. 57 (2), 178–188.

Robertson, H., 2018. Regional woven distribution: A resource and needs based building strategy for the remote Northeast Arnhem Land region of Australia.

Rowe, G., Frewer, L.J., 2000. Public participation methods: a framework for evaluation. Sci. Technol. Hum. Val. 25 (1), 3–29.

Rowe, G., Frewer, L.J., 2004. Evaluating public-participation exercises: a research agenda. Sci. Technol. Hum. Val. 29 (4), 512–556.

Rowley, K.G., O'Dea, K., Anderson, I., McDermott, R., Saraswati, K., Tilmouth, R., Jenkins, A., 2008. Lower than expected morbidity and mortality for an Australian Aboriginal population: 10-year follow-up in a decentralised community. Med. J. Aust. 188 (5), 283–287.

Russell, S., Ens, E., 2020. 'We 'don't want to drink that 'water': cross-cultural indicators of billabong water quality in remote Indigenous Australia. Mar. Freshw. Res. 71 (10), 1221–1233.

Seemann, K., Marinova, D., 2010. Desert settlements: towards understanding the mutuality of influence and scale-free network concepts. J. Econ. Soc. Pol. 13 (2), 5.

Seemann, K., Parnell, M., McFallan, S., et al., 2008. *Housing for livelihoods: the lifecycle of housing and infrastructure through a whole-of-system approach in remote Aboriginal settlements*: CRC for Desert Knowledge.

Slaughter, E.S., 2001. Design strategies to increase building flexibility. Build. Res. Inf. 29 (3), 208–217.

South, J., Fairfax, P., Green, E., 2005. Developing an assessment tool for evaluating community involvement. Health Expect. 8 (1), 64–73.
Spencer, M., Christie, M., Gundjarranbuy, R., Davis, V., Dhamarrandji, S., 2020. Our Homes.
Stafford Smith, M., 2008. The desert syndrome causally-linked factors that characterise outback Australia. Rangel. J. 30 (1), 3–14. https://doi.org/10.1071/RJ07063.
Stanley, J., Tomison, A.M., Pocock, J., 2003. Child Abuse and Neglect in Indigenous Australian Communities. Australian Institute of Family Studies Canberra.
Stewart, J., Anda, M., Harper, R.J., 2019. Low-carbon development in remote Indigenous communities: applying a community-directed model to support endogenous assets and aspirations. Environ. Sci. Pol. 95, 11–19. https://doi.org/10.1016/j.envsci.2019.01.003.
Sturman, A.P., Tapper, N.J., 1996. The Weather and Climate of Australia and New Zealand. Oxford University Press, USA.
ROOM TO BREATHE PROGRAM DESIGN GUIDELINES, 2019. TFHC (Retrieved from).
Udoeyo, F.F., Cassidy, A.O., Jajere, S., 2000. Mound soil as construction material. J. Mater. Civ. Eng. 12 (3), 205–211.
Webler, T., Tuler, S., 2000. Fairness and competence in citizen participation: theoretical reflections from a case study. Adm. Soc. 32 (5), 566–595.
Weiner, J., Glaskin, K., 2007. Customary Land Tenure and Registration in Australia: Anthropological Perspectives. ANU Press.
Wigley, J., 2008. Territory Housing SIHIP, Housing Design Guidelines for Remote Pubic Housing in the Northern Territory. Gutteridge Haskins and Davies, Darwin, September.
Wigley, J., Wigley, B., 1990. Community Planning Report: Barkly Region. prepared for ATSIC on behalf of the Jurnkurakurr Aboriginal Resource Centre.