Barriers to the adoption of green building materials and technologies in developing countries: The case of Burkina Faso

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Abstract. Due to declining resources, increasing population, and increasing pollution, green buildings, which utilize green construction materials and technologies, are emerging as part of the solution to mitigate these issues. Developing countries have understood the importance of incorporating sustainability as part of their national agenda. However, their ability to implement green design has been hampered by existing and/or perceived barriers. This paper strives to understand the barriers to green design and green materials implementation in developing countries, using the case of Burkina Faso, a country of West Africa. To gain insight on these barriers, this paper solicits the perceptions of Burkinabe green design professionals on sustainability issues involved with green design and construction. Five types of barriers are explored related to government, human, knowledge and information, market, and cost and risk barriers. An extensive literature review as well as the results of a study are used to examine this phenomenon as it compares to the existing literature. Understanding these barriers is the first step to initiate changes in policies and practices aimed at increasing green design in Burkina Faso. In addition, the research methods could be used to encourage further empirical studies on sustainable building practices in West Africa and other developing countries.

1. Introduction
Rising global environmental problems such as deforestation, land degradation, and pollution have necessitated professionals from all disciplines to rise to the challenge to mitigate these problems [1,2]. Buildings, while essential for shelter, can also exacerbate these environmental problems as well as have additional negative impacts on the economy, occupants’ health, and on society in general. A 2007 report by UNEP [3] found that the construction industry generates 30% of the total global annual greenhouse gas emissions as well as utilizing 40% of the total available global energy.

Globally, the importance of sustainability and sustainable development has been recognized by developed and developing countries. The degree to which these entities commit to sustainability plans and their ability to implement them successfully differs based on barriers to the implementation of sustainable projects and technologies [4]. Many developing countries have understood the importance of incorporating sustainability as part of their national agenda, but it is in their ability to implement those agendas that they trail behind developed countries due to a variety of barriers.

Many developing countries already suffer from fragile ecosystems, often experience severe environmental-related issues such as land degradation (i.e., erosion, aridity, deforestation,
desertification, drought, flooding, alkalinization and salinization). They also face acute water shortages, a situation which is expected to deteriorate due to climate change, as well as rapid urbanization with often inadequate infrastructure [5].

The adoption of green building practices and technologies has become standard in developed countries. However in developing countries, such as in Africa, its adoption has not yet reached that degree of success due to local and global barriers. There have also not been many studies carried out on defining and understanding barriers to the adoption of green building practices and technologies in developing countries. To mitigate these barriers as well as to gain a more complete assessment of sustainable development, one must be able to assess the knowledge and perceptions of concerned stakeholders on sustainability issues, especially as they deal with green design and construction and green materials. This will allow one to assess whether sustainable concepts follow through from theory to implementation. As such, the purpose of this paper is to investigate existing literature on barriers to green building practices and technologies in developing countries, and to make a parallel with the case of Burkina Faso.

1.1. Green design and green technologies
Green buildings are environmentally responsible structures and processes which minimize the consumption of resources during a building’s lifecycle [6]. Construction projects that include green building practices and technologies can reduce a building’s energy consumption by 30-80% [3]. Green buildings can also promote positive economic, environmental, and social benefits such as increased health and productivity, decreased absenteeism, decreased water usage, decreased energy consumption, and higher property taxes due to their higher desirability [7]. Green technologies in the design and construction industries are made up of materials, equipment, organizations, procedures and information systems [8]. Examples of green technologies can range from incorporating energy efficient windows and fixtures, green roofs, solar energy and shading, natural ventilation, water capture and grey water treatment, natural ventilation and energy efficient HVAC systems to name a few.

As the type of green technologies vary, so do their properties, degree of sustainability, and their applicability. Therefore, choosing the appropriate green building practices and technologies should depend on their local accessibility, availability, cost, climate, policies, and culture. For example, in traditional construction, incorporating an energy efficient HVAC system in a house in a developed country where such technologies are prevalent is fitting, but might not be suitable to a house in a rural area in a developing country such as Burkina Faso. In such instances, natural ventilation and shading might therefore be more appropriate.

1.2. Sustainable construction in developing countries
Various agendas regarding sustainable development have been developed since the 1992 Earth Summit in Rio in which Agenda 21 was agreed upon as a guideline for sustainable development, with each successive version striving to provide guidelines to incorporate sustainability in all aspects of human life. More recent agendas such as the special Agenda 21 for Sustainable Construction in Developing Countries (A21SCDC) have focused specifically on developing countries as they recognize that they require different approaches to meet their development goals by providing guidelines for their specific problems, scopes, development priorities, resources, skill levels, and cultures [9].

Another important agenda is the Sustainable Development Goals (SDGs) which was ratified by the United Nations General Assembly. This agenda laid out nineteen development goals which countries can use to meet their specific development goals by 2030. These various agendas have shown that billions of dollars have been and will be spent in Africa for sustainable development and in the built environment. Furthermore, Africa has the potential to be at the forefront of adopting and implementing green design projects and practices. Unfortunately, African countries have often not been able to reach their full potential in sustainable development. This inability to successfully implement sustainable
practices at a large scale or in the long run has also compelled some African countries to turn to developed countries for investments in the development of their infrastructures. Such aid on the one hand can be positive because it provides them the financial backing to develop necessary infrastructure, but on the other hand, it can leave them vulnerable to predatory lending practices.

Some critics have argued that there needs to be a new type of sustainable development in Africa because after fifty years of investment in infrastructure development, Africa in many cases has not seen the rapid economic growth, democracy, and social justice which was envisioned [9]. Although these various agendas stress the need for the participation of all concerned stakeholders, the past fifty years of development in Africa have highlighted the need for that new type of sustainable development for developing countries. This is because there often has been more of a focus on meeting development goals than on making sure that those goals are appropriate and can be maintained in the long term and in a sustained manner. To assess these agendas at the country level, there needs to be more research on sustainable development in Africa, especially in the area of understanding the barriers to the adoption of green building materials and technologies.

1.3. Burkina Faso

Burkina Faso is a landlocked country located in West Africa. Like various countries in Africa, it is a land of contrasts where one can find modern skyscrapers sitting next door to slums, where one can encounter the latest sports car driving alongside a donkey cart, or with rural areas which do not have electricity or running water, but where people own cell phones. Statistically it is considered one of the poorest countries in the world, which contrasts with its good road network and railroad system for travel and trade, as well as owning significant mineral deposits such as gold, zinc, manganese, copper, nickel and antimony [9]. With such vast resources, Burkina Faso should be one of the world’s richest and most developed countries. However, Burkina Faso, like many countries in Africa, is stuck in a cycle governed by poverty, fast urbanization, weak governance, the vestiges of its colonial past, as well as scarcity of vital resources such as arable land and water [9].

In the past 10 years, Burkina Faso has come a long way in implementing structural reforms to meet its development goals, especially in the area of economic growth where it has made enormous efforts to improve the competitiveness of its economy. Despite these accomplishments, Burkina Faso’s economy is still susceptible to outside influences such as market volatility for its staple raw materials (i.e., cotton, gold, oil), development limitations due to it being landlocked, and the volatility of the world’s finances. For it to continue to meet the UN’s Millenium Development Goals (MDGs) as well as its own “Burkina 2025” prospective national study, it needs to continue to develop in a constant, progressive, and sustainable manner [10].

Some of the sectors which have experienced the most growth include the mining and construction industries. With billions of dollars which will be spent on sustainable development and in the built environment, the construction industry is expected to increasingly contribute to the GDP. Despite the growth in the mining and construction industries, most of these projects to date have been funded via international aid or international/local partnerships such as NGOs, where the different stakeholders tend to have different agendas [9].

UN Habitat [5] predicts that by 2050, there will be an exploding increase in population globally, with the majority of that growth occurring in Africa and Asia. Furthermore, 60% of them are projected to live in urban settings. Africa already suffers from weak existing infrastructure, and this projected population growth highlights the need for new infrastructure to meet those needs. This is an opportunity to plan for and implement more green buildings which could incorporate a variety of site-specific green materials and technologies in order to mitigate the impact that these new buildings will have on the environment and resources.

The most widely used construction techniques in Burkina has primarily been earth-based due to the local climate, culture, and availability [11]. Although these techniques are considered to be sustainable, they require yearly maintenance, especially after the rainy season due to their lowered durability. Due to the increased availability of imported materials, as well as due to the desire to live in
“modern” buildings, there has been a noticeable increase in construction using imported materials such as cement, concrete, and steel. Hema et al. [12] found that 69.4% of dwellings in Burkina Faso used adobe for the walls, and 13.8% used hollow cement blocks. These figures have been shifting as cement-based constructions is becoming more popular due to its assumed modernity and durability. However, the manner in which these buildings are built, which oftentimes do not incorporate green design and green material technologies, makes them less adapted to the local tropical climate [12]. Furthermore, the fact that these materials are often imported, increases their cost, decreases their accessibility, and increases the negative impacts such buildings have on the environment.

Although the Burkinabe government has carried out some research and promotion of more “friendly local materials”, their usage generally had more to do with Burkina’s vernacular architecture, tradition, culture, material availability, lowered costs, and local labor and skills, rather than due to a conscious green design agenda. In the capital city, Ouagadougou, 48% of buildings are built using cement blocks for the building envelope. High rise buildings are generally made of concrete bricks, steel, or bricks with a concrete roof. 24.7% of houses are made of adobe blocks which grew from the traditional architecture, as well as being influenced by imported materials such as steel sheets. Finally, compressed earth block houses are the modern equivalent of the molded earth block [13].

Traditional construction in developing countries such as in Burkina Faso has generally used local materials. The choice of these building materials tends to be influenced by financial, social, and some sustainable factors. However, due to the lack of durability in traditional adobe construction, as well as the increase in availability of concrete, cement, and steel, one can anticipate that there will be a continued increase in the usage of non-sustainable building materials overtime. The usage of non-traditional materials will exacerbate the negative impact on the environment and existing infrastructures as more people are predicted to live in cities by 2050.

2. Literature review

Various studies were conducted to define, understand, and provide solutions to barriers to the adoption of green building practices and technologies in developed and developing countries. In the U.S., the top five barriers are cost, long payback periods, preferences for traditional building practices over new building practices, limited users’ knowledge and skills with green practices and technologies, and high costs. Other studies found other barriers such as resistance to change, lack of users’ knowledge and experience of green practices, and lack of government incentives to promote and build green buildings [14-17]. Studies in other developed countries, such as in Singapore or Australia, added the following barriers: lack of team communication during green projects, lack of research on barriers to green building practices and technologies, lack of green practitioners and market knowledge and interest in green building practices, uncertainty about their benefits and performance, high initial costs, lack of government support for green initiatives, lack of building codes and regulations, and poor stakeholder relationships [18,19].

Studies on barriers in developing countries have occurred primarily in Malaysia, China, Turkey, and India to name a few [20,21]. They reaffirmed the findings of previous studies in developed countries, as well as adding the following barriers: lack of databases and information on green building practices and technologies.

Chan & Darko [15] examined the existing literature and identified and categorized the 26 recurring potential barriers to green building practices and technologies. They condensed them into five barrier groupings: government-related barriers, human-related barriers, knowledge and information-related barriers, market-related barriers, and cost and risk-related barriers. In terms of research on barriers in Africa, there have been few studies in this area. When they have occurred, they have tended to be carried out in South Africa, East Africa, and Ghana and Nigeria for West Africa. Aktas & Ozorhon [22] stressed the importance of country specific studies on barriers to the adoption of green building practices and technologies to best identify local solutions. As such there is a need for such research as it applied to Burkina Faso.
3. Research methodology
This paper is based on a comprehensive literature review on barriers to the adoption of green building practices and technologies as well as a pilot study which was carried out as part of a doctoral dissertation. The pilot study tested a questionnaire survey and semi-structured interviews as part of its data collection methods.

3.1. Data collection methods
Questionnaire survey has been widely used in the design and construction industries as a method to collect professional opinions in green building research [23,24]. In this study, the questionnaire survey was developed to examine the issues influencing the adoption of green design and green materials, and to collect professional opinions from international green design experts. The semi-structured interviews conducted over the phone were meant to deal with the limitations of the questionnaire, enrich the data with qualitative data, as well as provide data triangulation [25]. The development of the questionnaire and the semi-structured interview questions were based off the comprehensive literature review. Prior to piloting them, questionnaire and semi-structured interview questions were reviewed by six international experts (two Burkinabe architects as well as four professors with over 10 years of experience in green building). Based on their feedbacks, the questions were refined and finalized.

The questionnaire was made up of 25 questions in English and French to accommodate the participants' local language. The questions comprise demographic questions, multiple choice questions, five-point Likert scale rankings (1=strongly agree to 5=strongly disagree) within matrix tables, and open-ended questions to allow the respondents to comment and expand freely on their views. The questions covered the following topics: participant’s profile, general perceptions about green buildings, drivers that support green design implementation in their respective country, questions that examine the five barrier groups (government-related, human-related, knowledge-related, market-related, and cost and risk-related barriers), and open-ended questions regarding their view of the future of green design in their country. The semi-structured interview was made up of 15 questions, which followed the structure of the questionnaire, to allow the participants to expand on their responses.

The questionnaire was answered by 10 expert participants who have a degree of knowledge of green building and green building materials: 6 participants were from Burkina Faso (5 architects and 1 researcher in Academia), 1 postgraduate researcher from Indonesia, and 3 participants from the U.S. (1 architect and 2 post graduate researchers). However, as this paper focuses on the case of Burkina Faso, only the results of the Burkinabe participants are covered in this paper.

3.2. Data Analysis
The questionnaire was distributed first via a secure link to the expert participants. Their suitability was defined based on their knowledge and understanding of green design and green materials, their educational background, working in a professional organization, and/or their publication in peer reviewed journals. Various statistical analyses including descriptive means, t-test were tested in the pilot for the questionnaire part of the survey, and the qualitative data from the qualitative part of the questionnaire as well as the semi-structure interviews were analysed using MAXQDA [26].

3.3. Results from questionnaire and semi-structured interviews
The participants from Burkina Faso were made up of 4 males and 2 females. Five of them were architects and 1 participant worked in academia. One participant held a certification, 2 held Bachelor degrees, 2 held Master’s degrees, and 1 held a PhD degree. Two had worked in the industry 0-5 years, 1 worked for 6-10 years, 1 worked for 11-15 years, 1 worked for 16-20 years, and 1 had 20+ years of experience. They primarily worked on residential, commercial, governmental, and educational projects. The majority of them (4) worked in the private sector, followed by 1 in the public sector, and 1 in academia. Half of them worked in small companies (1-4 employees), with the rest working in companies with 5-9 employees.
The most prevalent green technology that they have encountered or incorporated in their work were natural light (5), renewable energy such as solar (3), water conservation technologies (3), and incorporating energy efficient HVAC and appliances (2). They felt that green buildings had an advantage over traditional buildings in the areas of design & construction costs (6), durability (4), environmental benefits (4), and occupants’ health and comfort (3).

The recurrent themes regarding the biggest challenges to implementing green design in Burkina were: lack of knowledge on green design and construction for all stakeholders, lack of all stakeholder implication in green projects, lack of adequate policies focused on green architecture, lack of and/or limited access to green technologies, lack of education on green construction, and a low demand of green projects. The recurrent most important considerations for green design and construction were access to affordable construction, minimizing construction and operating costs, preservation of the environment, and preservation of cultural heritage.

The recurrent themes which emerged from the semi-structured interviews were that participants generally felt that the future of sustainable design and construction was promising if the following elements were applied. Firstly, the government should be more implicated in promoting green projects and should be leading the change towards more sustainable projects. Another recurrent theme had to do with having more green projects to serve as models to promote and inform on green design and technologies. They also felt that there should be more education on green design and technologies at all levels, and more diffusion networks on emerging technologies.

4. Discussion

Based on the existing literature, as applied to the questionnaire and semi-structured interviews, 26 recurring barriers are discussed below as they pertain to the 5 previously listed barrier categories.

4.1. Grouping 1: government-related barriers

The prevalent government-related barriers which emerged from the study dealt with the lack of/or ineffective government programs focused on green construction, lack of/or ineffective government policies concerning green construction, lack of government tax incentives available for green construction geared towards the public, and international sustainable design policies and standards not being adapted to fit local needs.

Burkina Faso has local codes and ordinances but there is currently no local green building rating system. Implementing a universal green building rating system could help promote green design by providing guidelines to meet green design goals, as well as recognizing efforts made in making buildings greener through tax incentives, global recognition, etc. However, there is also a need for local standards based on current needs and abilities, but which are also guided by existing global standards. This could help set up a future where a universal standard and performance rating system would be implemented as suggested by Ali & Al Nsairat [27]. Their goal was to develop an effective green building rating system for residential units in Jordan based on the local sustainable assessment tools. They simultaneously assessed international green building assessment tools to create new assessment items based on those international rating systems but which could also meet local conditions and needs.

The results also highlighted the need for technological training for project staff in green building projects [18]. In order to make such projects self-sustaining, project staff need to be knowledgeable in all parts of the projects, as well as being able to build, operate, and/or repair the incorporated green technologies. The Gando Primary School project in Burkina Faso by architect Francis Kéré is an example in how to design a green building while providing training for project staff [11]. It is considered sustainable because it was low-cost, fit the climate, used local resources (clay/cement brick hybrid), and could be built using local skills and labor. The success of the project also stemmed from the close involvement of the concerned stakeholders who worked together to build their school. As such, low-tech and sustainable techniques were developed, improved, and taught to the local population, providing technological training for them. Generally, green design projects in Burkina
Burkina Faso are funded in conjunction with outside donors, and do not often provide training for the staff or concerned stakeholders beyond being able to operate the green technology. The government could lay out policies which require training for staff and concerned stakeholders to be able to build, operate, and/or repair the incorporated green technologies themselves.

The final barrier which emerged from the results highlighted the need for more government promotion of green design and green materials. The Burkinabe government has promoted “friendly materials” such as with the LOCOMAT promotion (1991-2011) [12]. They could research what new green technologies could be successfully applied at the local scale to promote the vastness of green design and green materials. They would also have to simultaneously develop incentives to influence and reward stakeholders for implementing them in their construction. Currently there are few government incentives since the green building sector is still in its infancy in Burkina Faso.

4.2. Grouping 2: human-related barriers
From the pilot study, the prevalent human-related barriers which emerged dealt with the public having a low awareness of the benefits of sustainable construction, and the lack of or ineffective information diffusion networks on sustainable construction geared towards the public.

Studies on financial backing as a means of promotion of green building practices and technologies have shown that lack of or minimal financial funding can be major barriers to the adoption of green building practices and technologies in developing countries. This can exacerbate the already high initial costs of green building technologies even though they generally pay off in the long run [15,28].

Access to financial funding for construction projects is still a major issue in Burkina Faso. The World Bank estimates that about 28% percent of the Burkinabe population has access to financial services as compared to 93.5% of Americans in the U.S. Furthermore, despite good bank capitalization, interest rates are still considered high, at about 10 to 12 percent [10] as compared to the U.S. which has an interest rate of 2.5 to 4 percent [6].

However, access to micro financing has been increasing in Burkina Faso. In 2018, about 81 microfinance institutions (MFIs) were operating, and provided services to about 800,000 customers [9]. Governmental authorities have in recent years worked on improving the business environment and facilitating financial transactions. This has pushed most commercial banks to create or increase mortgage finance as part of their services, and as of 2016, almost all the commercial banks offered such services [6]. Therefore, to increase the development of green practices and technologies in Burkina Faso, more micro-financing as well as big scale financing should be developed. Furthermore, more promotion of the available financial possibilities should be carried out to increase the population’s knowledge of available services.

Another solution to increase the number of people who have access to banking services is to use cell phone, which is becoming increasingly popular even in some of the most remote locations. The local population is used to carrying out money transactions using their cell phones. By promoting mobile banking and financial services, this could increase the number of people who have access to financial services, especially in areas hampered by transportation and infrastructure limitations.

The final barrier in this category deals with stakeholders’ resistance to using new green technologies over traditional building technologies, often due to fears of liability and litigation, and to the lack of knowledge about the benefits and properties of green materials and technologies. This reluctance is further exacerbated if stakeholders feel that they have to be trained in its usage. However, this barrier is not specific to Burkina as it also occurs in developed countries [15]. In the case of Burkina Faso, minimal access to green technologies, minimal knowledge about them, and the lack of varied financial sponsorship, create more of a barrier to trying new green building practices and technologies, rather than a reluctance to try them.

4.3. Grouping 3: knowledge and information-related barriers
From the pilot study, the prevalent human-related barriers in Burkina dealt with the lack of or minimal availability for education (formal and informal) for design and construction professionals. Burkina
Faso has been experiencing a rise in architectural firms knowledgeable about green practices and technologies, as well as a rise in knowledgeable green architects, such as the architect Francis Kéré. There is a need for such professionals who are both knowledgeable about the local culture and context while also being knowledgeable about emerging green design materials and technologies.

Despite this rise in green design professionals, there is still a need for more access to sustainable education, for more green materials and technologies vendors, and the need for more financial sponsorships for education. The government could incorporate green design education both within existing education systems, as well as increasing the amount of formal green design education programs. They could also foster more partnerships with educational programs, such as with Fulbright Foundation, to provide more scholarships for students to study green design.

Much of the actual construction is carried out by local craftspeople who have more informal and hands on knowledge about construction, but who might not be knowledgeable about emerging green technologies and materials [22]. The government could create new fast track or modified programs which would allow them to benefit from their experience in the field, while becoming more educated on the components of green design and green materials implementation.

The final barrier in this category is the need for more readily available databases on green building practices and technologies, which could help promote the widespread sharing of information. Organizing local conferences on green design and green materials or inviting well-known global conferences to present in Burkina could also be a way to increase local awareness.

4.4. Grouping 4: market-related barriers

From the pilot study, the most prevalent market-related barrier in Burkina Faso dealt with the lack of green technologies available on the market. Research has found that in developing countries, limited or lack of access to green building materials and technologies has a major impact on the adoption of green building practices, especially when the developing country has to import them [22]. In the case of Burkina Faso, lack of access to green building materials have led to locals developing their own supply chains instead of waiting for suppliers or the government to supply them. For example, as sunlight is abundant in Burkina, with about 5.5 kWh/m²/day on average, the government so far has focused on developing solar farms to feed the electrical grid. However, since these are projects being developed with foreign donors, they take time to develop and implement. In the meantime, during the hot season, the existing grid cannot support the demand leading to rolling blackouts in cities [3].

Locals have either been traveling abroad to buy their own solar panels, or their demand has created informal supply networks to meet that demand. On the one hand, it is good because those micro networks help import green technologies, as well as help plug the lack of access to electricity in rural areas. On the other hand, it is seen as a loss for the economy as the government is not getting any taxes for them. It would be positive if the government could develop incentives to reward these users for connecting to the existing grid and being paid for selling their extra electricity.

4.5. Grouping 5: cost and risk-related barriers

On the one hand, research found that green materials tend to be more expensive than more traditional materials in their initial costs or in their installation costs, even though they may pay for themselves rather quickly. This is exacerbated when they are not manufactured in developing countries and need to be imported which increases their costs even more [15].

In the case of Burkina Faso, these additional costs tend to prevent the adoption of green building materials and technologies, especially for the population which is already struggling just to put a roof over their heads. However, as mentioned earlier, the more the government and other entities promote the benefits of green design and materials, the more access to financial loans and incentives increases, the more green design projects are implemented, and the more the demand for green materials increases. This in turn increases the demand, which stimulates their import and manufacture.

In terms of risk related barriers, the pilot results highlighted the fear of increased financial risks associated with sustainable technologies as the most prevalent barrier in Burkina Faso. This barrier is
prevalent both in developed and developing countries. The more readily available green materials and technologies are on the market, the less risky they appear. As the green market in Burkina Faso is still in its infancy, more promotion is required to advertise their benefits and performance capabilities [22].

5. Conclusion
The green design and green materials and technology adoption is projected to continue growing, especially as it pertains to Burkina Faso, and Africa at large. This paper examined barriers to said adoption from the perspective of Burkinabe green design professionals. Based on the limited research on barriers to green design and green materials and technologies adoption in Africa, this paper albeit being at a small scale, is expected to contribute to the body of knowledge in this area. This paper highlighted a variety of barriers as they fell within the five barrier groupings: government-related barriers, human-related barriers, knowledge and information-related barriers, market-related barriers, and cost and risk-related barriers. When possible, drivers and mitigation strategies were proposed based on the extensive literature review and results from the pilot study of the questionnaire and semi-structured interviews.

There are some limitations to the paper which will necessitate further research on this topic. Firstly, even though the sample size was adequate for a pilot study and some conclusion can be drawn from the results, it is nonetheless a small sample. As the pilot was carried out as part of a doctoral dissertation, further research utilizing a larger sample and comparing several countries in West Africa will be necessary to see whether the results would differ from those discussed in this paper.

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