
Analyzing Water Infrastructure and Community Resilience: A Technical Review on Kabalamapalaya Village

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Abstract: This research provides an examination of the water scarcity and infrastructure challenges in Kabalamapalaya, a rural village in the Tumkur district, India, conducted through the Live-in-Labs® program. The village, which accounts for 3,659 residents, relies on five borewells, whereas the main purifier has been non-functional for months. As a result, the lack of water and untreated sources facilitate numerous health risks. The conducted tests demonstrate the increased number of total dissolved solids, hardness, and chloride, which indicates an urgent intervention of the issue. The research process implies the phenomena of community engagement, resource mapping, and implementation possibilities, revealing the need for the Smart Observation App that is intended to monitor the available water quality and availability. The obtained results suggest the appropriateness of interventions usage and the raised issue's availability to be developed in a closer discussion within the rural development research by incorporating technology, sustainable water management, and community involvement.

Keywords: Water scarcity, Rural development, Sustainable water management, Live-in-Labs, Kabalamapalaya, Water quality

1. Introduction

Water scarcity is a severe problem based on the fact that more than 600 million people are experiencing high to extreme water stress in rural India. Kabalamapalaya is a village in Tumkur district, Karnataka, reflecting the same agricultural and rural issue on a nationwide scope. The community comprises 3,659 residents, including 995 households. There are five borewells in the village that are almost entirely dependent on them. Still, the people face extreme water scarcity issues [1], especially during the summer drought. One of the borewells remains out of service for more than four months. However, the people cannot use the other water sources since their purifier that desalinates the water had stopped working.

Analysis of water quality [2] has shown that TDS, hardness and chloride in the village's water are all above the safe limits. There is a need for urgent measures to be put in place to intervene and make the village's water safe and enough. As part of Live-in-Labs® at Amrita Vishwa Vidyapeetham, this study was supported by extensive fieldwork: resource mapping, participant observation and water quality analysis. It gives an all-round view of the existing water problems in Kabalamapalaya and says that public transport is bad, coupled with a dependency on daily wage labor adds to this maddening chaos. The research also highlights the need for a package of water management that integrates national, community-based and sustainable practices such as rainwater harvesting to achieve both water security for the village and better quality of life.

2. Methodology

A. Field Observations

A resource map and a transect walk were conducted at Kabalamapalaya, which is the field of observation to understand critical resources such as borewells (five) and water purifier(non–functional). The village had one electric transformer and insufficient public sanitation, leaving residents to rely on poorly-constructed septic systems at their homes. Using AEIOU framework based on the participant observation method– how life was affected by water scarcity, daily routine altered in a case where people have to fetch up to 1.2 km(40 litre/day designated amount) of water during summer months as the RO mechanism won't work.

B. Community Engagement

Community engagement through a series of group discussions and semi-structured interviews with stakeholders including daily laborers, homemakers, and village elders provided important insights regarding the existing socioeconomic challenges. The prominent elements include the existing reliance on wage labor and the opportunity to employ panchayat recognition as a way to access resources. Initially, the planning team has employed the scenario planning tool to investigate the feasibility. The findings have revealed some practical and cultural barriers and the overall complex multi-leveled nature of the two options. Additionally, the team has further investigated the existing income and expenditure data and inflow-outgrowth dynamics and found that “buying water from available sources was a major household expenditure, especially in summer”.

C. Water Quality Testing

The quantitative data was the comprehensive water quality testing data obtained from the village’s borewells. The test was done by Sneha Test House, a laboratory that is recognized by the Ministry of Environment, Forest, and Climate Change, Government of India. The test focused on the key parameters that include the pH range, total dissolved solids and water hardness, chloride content, and the microbial contents of the water which in this case is Escherichia coli and total coliforms. These are important as they determined whether the water was fit for consumption by residents.

D. Venn Diagram Analysis & Seasonal Calendar

A tool used by the team in data analysis was a Venn Diagram Analysis to show the relationships and overlaps between community resources, stakeholders, and issues in Kabalamapalaya, pointing at the gears through, which water scarcity is taking place. It was found from the analysis that some borewells are more dependent, such as the one in the top-left box. However, they are poorly supported by corresponding water purifiers in the top right and left spaces. In addition, the Seasonal calendar shows that many of the people are stressed by water scarcity during the dry season, or around June to August. In terms of socioeconomic statuses, the households, which tend to fall short, in terms of solutions to water scarcity are low-income earners.

E. Problem Tree Analysis

The Problem Tree Analysis was employed in order to outline and explore the causes and effects of water scarcity in Kabalamapalaya. Initially, the principal issue of the lack of access to clean water became the ‘trunk’ of the tree. Further, the ‘branches’ diverged into the malfunctioning purifier, seasonal crisis, and economic and social constraints. Moreover, to preserve the structure, the causes were divided into three relevant groups, namely, technical, economic, and environmental. Another essential outcome was the creation of an effects branch that outlined how the primary cause affected the community in terms of health, living standards, and economic pursuits. The final structure allowed for the rationally sound identification of the most critical root causes that would.

3. Results & Discussions

A. Field Observations

The resource mapping in Kabalamapalaya has identified one of the key challenges and resources. Five borewells and few 3000-liter storage tanks are the main source of centralized water supply. However, all village’s water is connected to one filter, which makes the quality and the quantity of water insufficient and unsafe. The same is true for electric supply since the transformer powers the whole village, which makes the system vulnerable. Few

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Kirana shops and certain other specialized businesses provide for local commerce, but there is a potential for economic development. Azim Premji Foundation provides for health and childcare services, and there is an opportunity for early upbringing and development. However, I believe, the main challenge is a significant environmental hazard. Lowland areas and ditches are full of garbage and wastes, and they are not maintained since the government is not helping.

Fig. 1. Resource Map

The Transact Walk in Kabalamapalaya has provided valuable insights into the state of infrastructure, water management, economic activities, and social context. It validated the position on the lack of infrastructure in many places, particularly the terrible conditions of the roads by the railway line and in low residential places. It also found that public transport cannot meet people’s needs, as their operating hours do not match the working hours. The state of water management is similar, as the purifier is not enough to meet peak time demands. Sanitation in particular has worsened, as the toilets are all closed and others are unusable. The local economy remains of poor character, and the local business activity, most notably the wholesale Pani-puri shops, should be supported. The social context is better than many places, as the Azim Premji Foundation clinic seems to be doing well, and the Mosque is an important social and cultural hub.

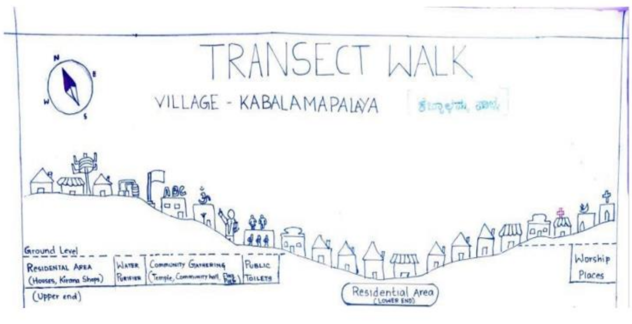

Fig. 2. Transect Walk

AEIOU worksheet observations showed that water scarcity is a significant issue, which affects daily life routine in the village. Women and children have to spend a lot of time fetching water from the borewells. Moreover, the problem of infrastructure causes households to have to keep water in an inappropriate manner with the use of drums, etc. However, in such a way, people become at the risk of getting some diseases associated with poor sanitation. The assessment identified human needs and challenges. The social aspect also involves strong community engagement accompanied by a high level of dependency of people on informal networks. These people, by not securing water, are at risk of affecting their health, education, life, and productivity.

B. Community Engagement

The data in terms of income and expenditure illustrate the economic precariousness of the lower sections of the community. The 75% of the population of the village are daily laborers – who receive Rs. 18,000. The expenditure is estimated at Rs. 14,000, and it includes the means to pay for groceries, electricity and other supplies needed to sustain life. It should be noted that the family with only one earning individual is under even greater pressure in terms of income at about 15,000 Rs., and rest is spent in an almost equal manner on accommodations, groceries and electricity. It is apparent that the money is spent entirely on basic life necessities and is not put aside. In such a way it should be assumed that due to their narrow margin of finance, these two groups are particularly prone to sudden economical shocks, which is facilitated by the fact that they do not have any savings.

Table I. Income & Expenditure

Village Community	Income (Rs.)	Expenditure (Rs.)	Expenditure Details
Community Workers (12 members)	20000	16000	School fees, Electricity, Daily needs, Grocery
Shopkeepers (9 + 2 retail)	30000	22000	School fees, Grocery, Stocks (goods), Electricity
House Maid (10% of population)	18000	14000	Grocery, Electricity and Others
Mason (5-10% of population)	25000	18000	School Fees, Grocery, Electricity and Others
Daily Labors (Except Mason) (75% of population)	18000	14000	Grocery, Electricity and Others
Daily Labors (1 person earning in the house)	15000	14000	Groceries, Electricity and Others
Net	**126000**	**98000**	--

Raw material inflows for garland and Pani Poori production with elements re-exported such as manual labor demand and JCB service provision. The outflows include the final garlands and Pani Poori, with other services and some goods from outside sources. This demonstrates the village's reliance on items such as functions and socials, building materials, and energy, as there is only one transformer and limited LPG and Petrol used. There is an issue with the inadequacies in waste management, trash from 995 housings comes to the village, but there is no corresponding outflow management. The low rate of livelihood available, which involves mainly smithy work and temporary occupancy at a car sales showroom, highlights the need for an increased number of flows, robust infrastructure, improved waste management services, and more.

Table II. Inflow & Outflow

Commodity	Inflow	Outflow
Water	≈ 3000 people (20L per person)	NA
Sanitation	NA	NA
Health	Medicines	NA
Hygiene	NA	NA
Agriculture	NA	NA
Risk Management	NA	NA
Waste Management	NA	NA
Education	NA	NA
Livelihood	• Raw materials for garlands - 20 houses	• Pani Poori (5 Wholesale shops)

	• Refined Flour for Pani Poori making - 5 houses	• Backhoe Loaders (JCB Service) 2 families- driver and owner • Manual Labour • Garland (20 houses)
Energy	Petrol ≈ 50-90 own vehicles • LPG - 10-15 autos • Transformer - 1	NA
Environment	Garbage - from 995 houses	NA
General	• Groceries • Building Materials • Cloths • Online Food Delivery • Ecommerce	NA

C. Water Quality Testing

The testing of water quality in Kabalamapalaya showed that both of the village's primary borewells have substantial issues. For Borewell-I, the pH value of 7.86 was generally acceptable, but Total Dissolved Solids at 658 mg/L, Total Hardness at 317 mg/L, and Chloride at 319 mg/L were all elevated. There was no bacterial contamination found, and the presence of these dissolved solids and the water hardness could cause long-term issues with health and water taste and utility.

Table III. Borewell-I Chemical Test

SL No	Parameter	Units	Results	Maximum Acceptable Limit as per IS:10500-2012	Maximum Permissible Limits in The Absence of Alternate Source as per IS:1500-2012	Test Method
1	Colour	Hz	<2.0	15	15	IS 3025 (Part 4)
2	pH value	-	7.43	6.5-8.5	No relaxation	IS 3025 (Part 11)
3	Turbidity	NTU	<0.1	1	5	IS 3025 (Part 10)
4	Total Dissolved Solids	mg/l	658	500	2000	IS 3025 (Part 16)
5	Calcium (as Ca)	mg/l	99.9	75	200	IS 3025 (Part 40)
6	Chloride (as Cl)	mg/l	319	250	1000	IS 3025 (Part 32)
7	Fluoride (as F)	mg/l	<0.1	1.5	1.5	APHA 24th Edition
8	Free residual chlorine	mg/l	<0.1	0.2 min	0.2 min	IS 3025 (Part 26)
9	Iron (as Fe)	mg/l	<0.05	No relaxation	No relaxation	IS 3025 (Part 53)
10	Magnesium (as Mg)	mg/l	16.8	30	100	IS 3025 (Part 46)
11	Nitrate (as NO3)	mg/l	31.6	45	No relaxation	IS 3025 (Part 34)
12	Total alkalinity (as CaCO3)	mg/l	318	200	600	IS 3025 (Part 23)
13	Total hardness (as CaCO3)	mg/l	317	200	600	IS 3025 (Part 21)
14	Sulphate (as SO4)	mg/l	313	200	400	IS 3025 (Part 24) Sec I
15	Electrical Conductivity	uS/cm	1096	No max	---	IS 3025 (Part 14)

Table IV. Borewell-I Microbiological Test

SL No	TEST PARAMETER	UNITS	RESULTS	LIMITS AS PER IS: 10500-2012	TEST METHOD

1	Escherichia coli	100 ml	Absent	Absent	IS: 15185: 2016
2	Total coliforms	100 ml	Absent	Absent	IS: 15185: 2016

Borewell-II showed the most alarming results, as TDS was at the level of 974 mg/L, whereas Total Hardness equaled 415 mg/L, which is also above permitted limits. The chosen place contained water with relatively high levels of Chloride, which amounted to 498 mg/L. Furthermore, Escherichia coli was not found in the sample, yet it still showed that Total Coliforms were present, suggesting microbial contamination. Therefore, the quantitative analysis of the available samples indicates that the villagers will need to consider the immediate intervention to ensure that the members of the community have access to clear water. The necessity of the identified measure is especially critical in Borewell-2 because of the presented data, and the residents of the tested area will have to make a decisive choice.

Table V. Borewell-II Chemical Test

SL No	Parameter	Units	Results	Maximum Acceptable Limit as per IS:10500-2012	Maximum Permissible Limits In The Absence of Alternate Source as per IS:1500-2012	Test Method
1	Colour	Hz	<2.0	5	15	IS 3025 (Part 4)
2	pH value	-	7.28	6.5-8.5	No relaxation	IS 3025 (Part 11)
3	Turbidity	NTU	<0.1	1	5	IS 3025 (Part 10)
4	Total Dissolved Solids	mg/l	974	500	2000	IS 3025 (Part 16)
5	Calcium (as Ca)	mg/l	147	75	200	IS 3025 (Part 40)
6	Chloride (as Cl)	mg/l	498	250	1000	IS 3025 (Part 32)
7	Fluoride (as F)	mg/l	<0.1	1	1.5	APHA 24th Edition
8	Free residual chlorine	mg/l	<0.1	0.2 min	1 min	IS 3025 (Part 26)
9	Iron (as Fe)	mg/l	<0.05	1	No relaxation	IS 3025 (Part 53)
10	Magnesium (as Mg)	mg/l	26.5	30	100	IS 3025 (Part 46)
11	Nitrate (as NO3)	mg/l	32.8	45	No relaxation	IS 3025 (Part 34)
12	Total alkalinity (as CaCO3)	mg/l	477	200	600	IS 3025 (Part 23)
13	Total hardness (as CaCO3)	mg/l	475	200	600	IS 3025 (Part 21)
14	Sulphate (as SO4)	mg/l	30.9	200	400	APHA 24th Edition
15	Electrical Conductivity	µS/cm	1624	---	---	IS 3025 (Part 14)

Table IV. Borewell-II Microbiological Test

SL No	TEST PARAMETER	UNIT S	RESULT S	LIMITS AS PER IS: 10500-2012	TEST METHOD
1	Escherichia coli	100 ml	Absent	Absent	IS: 15185: 2016
2	Total coliforms	100 ml	Present	Absent	IS: 15185: 2016

D. Venn Diagram Analysis & Seasonal Calendar

The Venn diagram insights reveal that the Azim Premji Foundation, though distant, is highly trusted for educational and health services, while the Primary Health Centre (PHC) and Police Station (PS), also far from the center, hold moderate trust. Government and Private Schools are less accessible but moderately trusted, whereas Ward Members are centrally located, making them highly accessible and moderately trusted for governance. The Temple and Water Filter, both centrally positioned, are highly accessible and trusted, serving as key community hubs. The Community Hall and Dalit Sangharsha Samiti (DSS) are also centrally located, making them accessible and highly trusted for community events and advocacy. The Panchayat office is accessible and moderately trusted for governance, while the Post Office, despite being far, is moderately trusted for postal services. Teachers and the Playground, both near the center, are highly accessible with high and moderate trust respectively, and Shishu Pal, likely a childcare center, is accessible and moderately trusted by the community

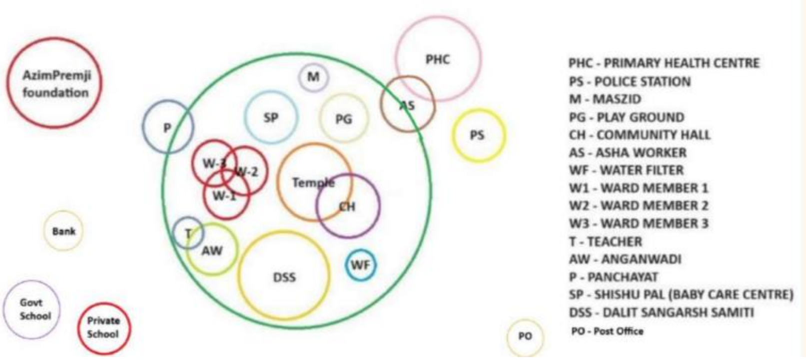

Fig. 3. Venn Diagram

This calendar has been made by using data from the previous years, and it shows water supply data and its fluctuation throughout the year. From the calendar, it could be identified that the borewell water levels are under more stress and decrease implying “not enough water” from “water not needed. Call it a day” which starts from “May month”. To overcome this stress, we have come up with Smart Observation App. This app will monitor continuously giving the data at that time not based on the previous years. So, this gives the clear current data on water usage patterns flow and the levels. This will help the community to manage the other sources of water during the time when they see a downward flow making them be managed proactively and prevent the shortage of water.

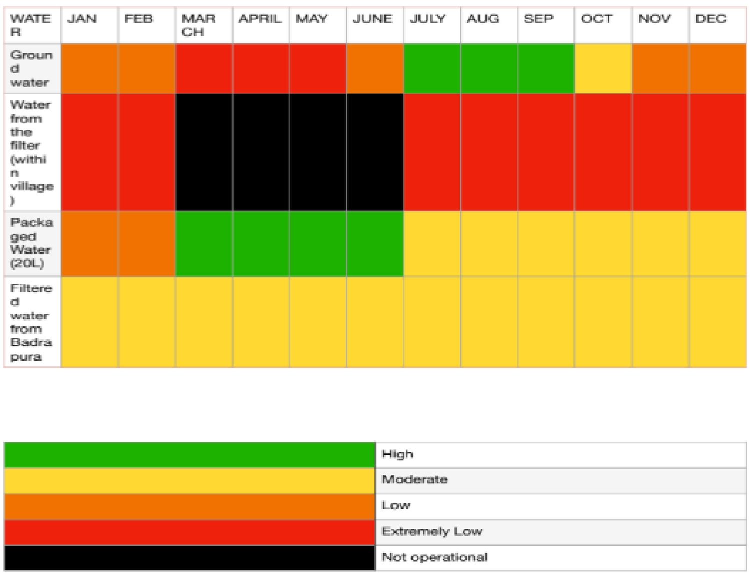

Fig. 4. Water Availability Seasonal Calendar

Similarly common disease calendar shows that, viral fever, dengue, dysentery diseases increases due to the lack of water quality and unavailability of clean water especially on monsoon and hotter months. So it is necessary to have Proper water management with good sanitation facilities.

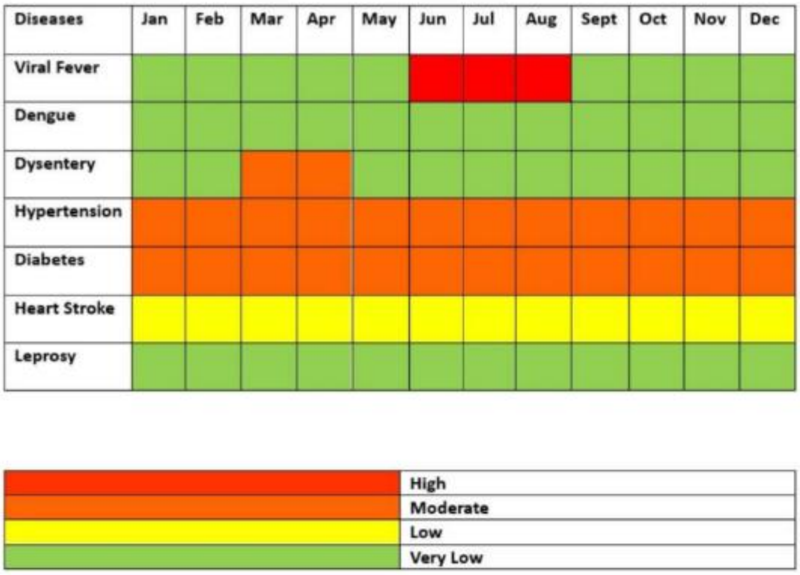

Fig. 5. Diseases Seasonal Calendar

E. Problem Tree Analysis

Water scarcity is the major issue faced by the people of Kabalamapalayam, particularly in summer. This issue is not only due to the concept of season but also due to economic constraints, non-functioning of water purifiers, and borewell's depth collapses. Even though there are many people who are stubborn to spend their income, there are about 10% – 15% households those who experience the constraints of income and are unable to invest in an alternative source of better type of water issue. Transport facilities are also not available to travel to carry water even though rental costs are high to do the same. The non-function of the water purifier representing 1000 liters waste [3] for every 3000 liters is used. Collapse of the 5 over the 9 bore wells depicts that only four bore wells are available for extracting water. Such a scenario of water scarcity forces the people to put up fatigue, frustration and, in the long run, health issues like chronic neck and back pains. This problem is robust among the daily wagers and low-income household people.

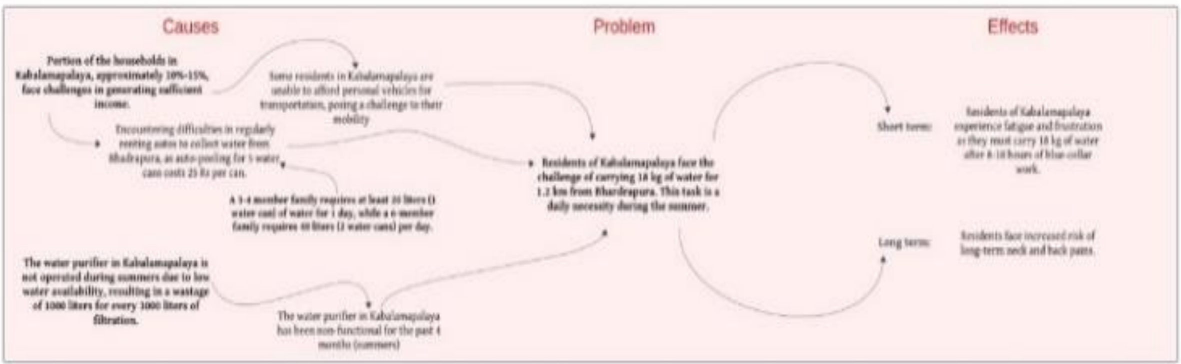

Fig. 6. Water Problem Tree

For Kabalamapalaya, in terms of short term achievements, repairing the dysfunctional water purifier in 1-2 months to reduce the burden of residents traveling to get water from too far sources is important. Furthermore, to reduce the physical constraints, a road can be made going through IRIDM to shorten the length of the 1.2 km to 630 meters to facilitate the process. However, as a way of complimenting this strategy, the use of an Observation App should be initiated. The app will be monitoring and updating the masses about the water quality and availability progress from the sources within the village. This will provide a concise and complete analysis and insights that will help in initiating timely interventions and the emergences of the long-term objectives which can be met from engineering solutions [4]. The apps can, for instance, be used to initiate or install appropriate water filtration machine/system needed in the place in the form of products.

4. Conclusion

To sum up, Kabalamapalaya constitutes a challenging area in terms of water management, infrastructure, and economic sustainability. The transect walk and other types of field observation highlighted that such key problems as the dependence on a limited number of overpumping bowels, lack of public transport, and inadequate conditions in terms of sewage systems still existed there. The vulnerability of people from this community is predetermined by their substantial dependence on daily waged works and considerable tension that they experience while transferring water from the distant fields and other sources. Nevertheless, the described area also appears to be durable and socially strong, which can be viewed as a solid foundation for further interventions. Their successful implementation will allow improving the current state of the water in this area, as well as boost the infrastructure and opportunities for economic sustainability. The focus on the application of technologies should be made. In this context, a Smart Observation App is likely to be discussed as an option that will allow for the real-time tracking of water quality and its availability.

Acknowledgment

Moreover, we want to thank everyone who contributed to the success of our project in Kabalamapalaya village. First and foremost, we are thankful to the Live-in-Labs® team. Their guidance, resources, and encouragement were instrumental in the planning and execution of our project. The experience and knowledge they shared with us were invaluable and greatly enriched our learning.

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