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Research Paper

Construction Materials Waste Management Practices on Ajima Chacha Mega Irrigation Projects in North Shewa, Ethiopia

Shumet Getahun Reda[1], Mohammed Adam[2]
[1] *Lecturer at Faculty of Civil and Water Resources Engineering, Bahir Dar University, Bahir Dar, Ethiopia. (Shumet.Getahun@bdu.edu.et)*
[2] *Project Engineer at Amhara Water Works Enterprise, Debre Birhan, Ethiopia (mohammedademen@yahoo.com)*
Corresponding Author: Shumet Getahun Reda (Shumet.Getahun@bdu.edu.et)

ABSTRACT
Efficient material management is essential to have productive and cost efficient construction site. This paper aims to investigate the cause of construction material wastage in Ajima Chacha Mega irrigation projects, north Ethiopia. A questionnaire survey study with interview was used to explore construction materials management practices. Thirty three questionnaires were distributed to project managers, project engineers, site engineers, office engineer, and contract administration for the research. The construction material management practice in Ajima Chacha mega irrigation project is found poorly performed. Poor material handling and storage by contractors is the main cause of the construction material wastage in Ajima Chacha Mega project construction sites.

Keywords: *Causes, Construction, Material, Management, Wastage*

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I. INTRODUCTION

Construction is the process of physically erecting the facility by utilizing construction equipment, materials, and supplies which is guided with appropriate supervision and management. Construction projects are complex, basically involving owners, architects, engineers, contractors, suppliers and vendors [1].

The development of construction industry has caused problems in the generation of construction wastes in many developing countries and expectations of natural resources to large extent. Depending upon the type of structure, the cost of construction materials may be up to 65% or more of the total cost [2]. Research has shown that construction materials and equipment may constitute more than 70% of the total cost of a project. As projects get bigger, complexity, and materials management becomes more sophisticated. It needs the use of appropriate tools, and techniques to ensure other things that materials are delivered on time, stock levels are well managed and the construction schedule is not compromised. The result of improper handling and managing materials onsite during construction process affects the total project cost, time and the quality [3], [4].

Construction waste is material that needs to be moved to another place from the construction site or to be used for other purpose. Different factors contribute to the generation of material waste. These factors have been grouped in to four; design, procurement, handling of materials, and operation [5], [6], [7].

Building material waste is the deduction between the cost of supplied materials on site and those appropriately used as specification in the work deducting the cost saving of replaced materials. Construction and demolition waste is a substance produced during site clearance, land excavation, demolition, building reconstruction and other civil works in the form of rubble, debris, concrete, steel, wood, and mixed form [8], [9], [10].

Waste sources can be controlled during the design stage and management phases. Waste can be categorized according to its source. It may result from the process preceding construction, such as material manufacturing, design, material supply, and planning as well as the construction stage [11] [12]. Waste production on construction sites is usually high due to inappropriate storage and protection, poor handling and control, excess ordering of material, theft, and damage of material during receiving [13], [14], [15].

A waste reduction strategy should be developed for each main source. The strategies are identified and classified based on their importance in controlling and alleviating the source of waste. Resource management is one of the main obstacles in the development of the Ethiopian construction industry [16].

Most projects demand more resources than the amount originally estimated. If the material waste is not properly handled and managed on the project site, this will lead to cost overrun, and eventually negatively impact the project performance and the environment. The construction industry yields a high amount of waste leading to environmental pollution and CO_2 emissions [17], [18], [19]. The Construction industry is the major beneficiary of innovations from the field of construction management quality. For effective and efficient accomplishment of construction projects and to increase their probability of success, project waste management concepts are undoubtedly necessary [20], [21], [22].

Site waste management plan (SWMP) is currently familiar as a valuable system for the purpose of assisting construction parties to exercise the type of construction and demolition waste. The effectiveness of SWMP is constrained by site limitations and overhead costs. The majority of sites do not have sufficient space to perform on-site sorting and the application of SWMP is rare in private projects [20, 23].

In the last 20 years, extensive building and infrastructure development projects have led to an increase in the generation of construction waste material. Due to lack of compulsory requirements in the green building assessment tool, planning for waste is not widely practiced in the construction industry. Appropriate design can significantly reduce waste generation at the very beginning stage of construction which includes coordination and standardization, use of recycled materials, using low-waste building technologies, backfilling cut and fill by the excavated materials, modelling design information could evaluate optimized design solutions. Future research on how to properly design out waste is necessary [20], [24].

Purchasing an appropriate quantity of raw materials, good coordination between store and construction personnel to avoid over-ordering, adoption of proper site management techniques, training of construction personnel, and accurate specifications of materials to avoid wrong ordering are some of the methods for reducing materials waste. Optimization of worker productivity, minimization of duplication of handling of materials, lowering the chance of weather damage, improved budget accuracy and forecasting, and greater adherence to project milestones are the main benefits of waste management [25], [7].

Based on the literature review, few researches have been done on construction waste management in Ethiopian irrigation projects, specifically Ajima Chacha Mega projects. Therefore this paper finds the gaps in construction waste management practices, and sets recommendations.

II. MATERIALS AND METHODS

Ajima-Chacha Dam and Large Scale Irrigation project Infra-structure are located in Angolelana Tera and Basona Werana woredas, within nine and one kebeles of the woreda's respectively, North Shewa Zone, Amhara Regional State, Ethiopia. Its geographic location is between the extremes of the command; positioned at1055323 to 1053394UTM Northing and 552313 to 557923UTM Easting within the radius of 20 km from the river Ajima in the North and South direction and 12 km to the East direction from the Woreda town, Chacha.

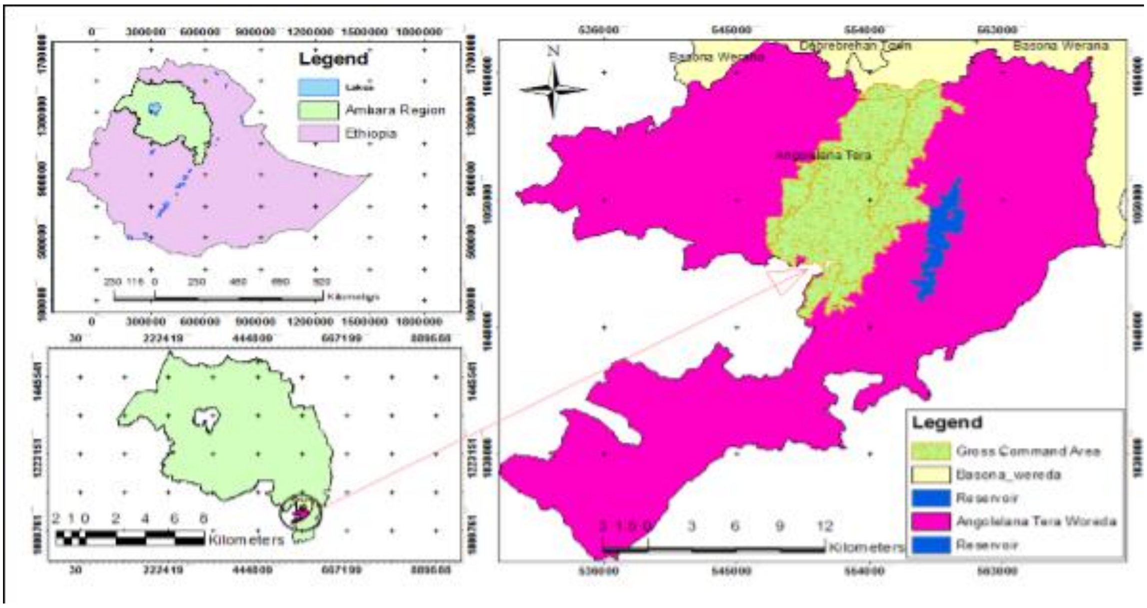

Figure 1: Location Map of the Project

The research aims to study the causes and magnitude of wastage of construction materials on construction project sites. To achieve the research aim, the researcher prepared a questionnaire form that included questions about the causes of wastage and the estimated percentages of wastage of materials used on construction sites in Ajima Chacha mega irrigation project. Before the final formulation of the questionnaire form, a pilot survey was conducted. The form was revised in accordance with the feedback received.

Data was collected through site assessment and literature review. The data for this study is retrieved from secondary sources and questionnaire. Experience and observations from reality were used for formulating the research statement of problem. An investigation on the causes of construction material wastage and its impact on projects which are under contractor of Amhara Water Work Construction Enterprise (AWWCE) was carried out.

The data was collected mainly through interviews and questionnaires. Field observations through site visits were also employed to gather data on high waste generating construction materials. Applied and explanatory collected data because the research was initiated from practical problems and investigates why construction material waste occurs on construction project. The site visits involved observations where the researcher sought to find out how materials were stored and handled and also to provide a compendium on high waste generating construction materials used in the construction industry. The project manager, contract administration, project engineer, site engineer, and office engineer and quantity surveyor construction projects with contractors were involved in interviews and questionnaire survey. To determine the minimum sample size that is representative of the population the Kish Formula, which gives a procedure for calculating the minimum sample size was used [26]. The formula works as follows

$$\mathrm{n} = \frac{n'}{(1+\frac{n'}{N})} \quad (1)$$

Where n = Sample size N = total number of population

$\mathrm{n}' = \frac{s^2}{v^2}$ s^2 = the maximum standard deviation of the population = 1.96^2

v^2 = the standard error of sampling distribution = 0.05 or 5%

The answers for the structured part of the questionnaire are based on Likert's-scale of five ordinal measures of agreement towards each statement from 0 to 4 as shown in the following sections. Likert's-scale is important, to provide simplicity for the respondent to answer, to make evaluation of collected data easier, know respondents' feelings or attitudes about something [27]. After the variables of management quality in water supply construction projects are identified; respondents are asked about their agreement on these variables in causing defect. Scales given are, 1, I strongly disagree, 2, I don't agree, 3, Neutral, 4, I agree and 5, I strongly agree.

After expressing their agreement or disagreement on the construction management, quality respondents are asked about the chances of occurrences of these variables based on the following choices. 0- Not at all = 0%

probability to happen, Unlikely = 0% - 25%, Likely = 26% - 50%, Almost certain = 51% - 99% and certain = 100% probability to happen.

After identifying the chances of occurrence of quality problems, respondents were asked about the impacts of each cause of management quality on construction based on the following choices. 0- No significance, 1-Minor significance, 2-Average significance, 3- High significant and 4- Extreme significance.

Having data gathered causes of poor construction material waste management on construction sites, the responsible party from stakeholders in the construction industry has to be identified for the cause of poor construction material waste; the questionnaires are prepared in such a way that detailed information can be gathered in a systematically prepared matrix table. The "Relative Importance Index" analysis method is adopted to establish the relative importance of construction material waste on construction projects. Data was analyzed by calculating frequencies and the Relative Importance Index (RII). The Relative Importance Index (RII) is calculated as follows[28](2015)[28](2015)(2015).

$$RII = \frac{4n_1 + 3n_2 + 2n_3 + 1n_4 + 0n_5}{4N} \quad (2)$$

Where:

N = Total number of respondents

ni = the variable expressing the frequency of the i^{th} response.

n_1, n_2, n_3, n_4, n_5 are Number of frequency 'extremely significant', 'very significant', 'moderately significant', 'slightly significant' and 'not significant' respectively. The levels of response are: extremely, very, moderately, slightly, and not significant for 100%, 75%, 50%, 25% and 0% respectively.

The Cronbach's alpha is a tool for assessing reliability scale and co-efficient normally ranges between 0 and 1. According to the rule of thumb for describing internal consistency using Cronbach's Alpha, the closer the Cronbach's Alpha coefficient is to 1, the greater the internal consistency of the items in the scale. Coefficient alpha was developed as a generalized measure of the internal consistency of a multi-item scale. It is formulated as equation 3 & 4 [29].

$$\alpha = \frac{k}{(k-1)}(1 - \sum_{i=1}^{k} \frac{\sigma\, i^2}{\sigma s^2}) \quad (3)$$

$$\frac{kr}{1 + r(k-1)} \quad (4)$$

Where k is the number of items in the scale, **di²-** is the variance of item i, **ds²** is the Variance of the scale, and r is the average inter-item correlation. Excel calculation is chosen for Cranach calculation. The Cronbach's alpha coefficient of scale should be above 0.7. However, it is common to find low Cronbach's alpha coefficients, for example, 0.5 for scales with fewer than ten items. Moreover, the reliability of a scale varies depending on the sample used.

III. RESULTS AND DISCUSSION

a. Description of Study Area

After the questionnaire survey was carried out, statistical analyses were undertaken on the responses using various methods described in the research methodology. Response Rates Out of a total of 73 questionnaires distributed 36 of the respondents returned the forms and 33 of the forms were completed. As shown in Fig.2, contractor's response rate was 88%, clients were 100%, and consultants were at 91 % response. The average response rate is about 93%.

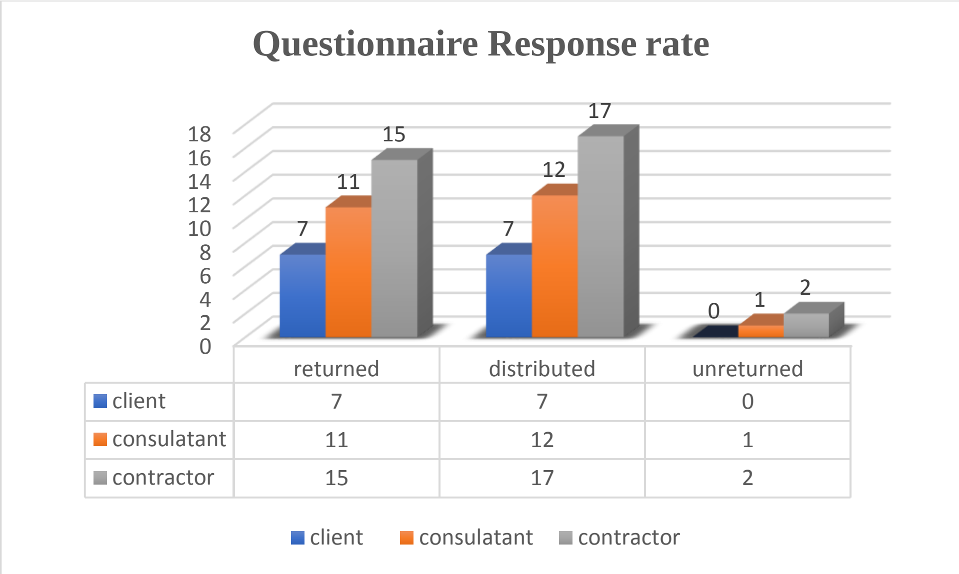

Figure 2: Questionnaire Response Rate

Fig. 2 shows the current position held by the respondents in the company. These positions include contract administrator, project managers, project engineers, site engineers, and office engineer, and client representative.

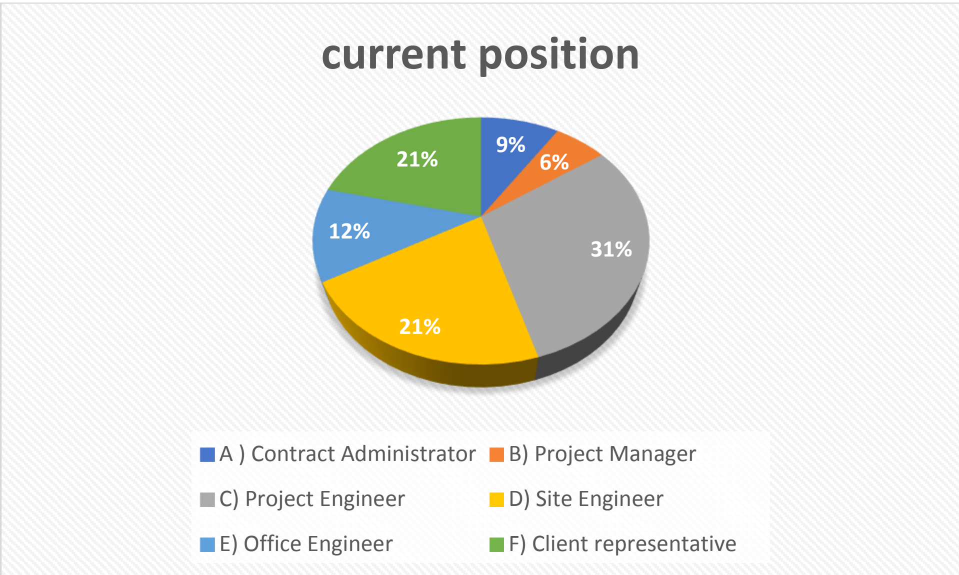

Figure 3: Position of Stakeholder

The overall Cronbach's alpha coefficient for all scaled questions in the study was 0.88; there is good internal consistency in the variables. Table 1 shows the reliability test summary for questions 4 and 5 included in Appendix A. The Cronbach's alpha coefficient was calculated and the subsequent relationship between the individual items and the overall scale was examined. Where deemed necessary to increase the level of reliability, appropriate items were removed; subsequently improving the reliability marginally.

Table 1: Summary for Reliability Test.

Questions	Sources	Cause	Effect on Project	All Questions Combined
Number of Item	45	25	3	73
Cronbach's alpha	0.91	0.89	0.85	0.88

There are many factors, which contribute to construction materials waste generation on site. Waste may occur due to one or combination of many causes. Literature review parts the sources of waste classified under five categories: those are design and documentation, site management and practices, Materials handling and storage, operation and site supervision.

Group 1. Design and documentation factors

Respondents were asked to score which factors are considered to be major causes of waste arising from design and documentation. Table 2 shows that the Relative Importance Index (RII) and Rank (R) of all the 9 causes of waste evaluated for the respondents. This means that all the nine factors are considered as causes of waste arising from design and documentation.

Table 2: Ranks of Construction Materials Wastage due to Design and Documentation factors

	Contractor		Consultant		Client		Weighted Avg.	
Group 1. Design and documentation	**RII**	**R**	**RII**	**R**	**RII**	**R**	**RII**	**R**
Design changes and revisions	0.82	1	0.47	2	0.28	7.00	0.52	1.00
Selection of low quality products	0.63	6	0.57	1	0.33	1.00	0.51	2.00
Lack of knowledge about construction techniques during design activities	0.72	3	0.47	2	0.33	1.00	0.51	3.00
Poor communication leading to mistakes and errors	**0.72**	3	0.47	2	0.33	1.00	0.51	3.00
Lack of attention paid to standard sizes available on the market	0.77	2	0.37	8	0.33	1.00	0.49	5.00
Lack of information in the drawings	0.68	5	0.47	2	0.28	7.00	0.48	6.00
Poor/ wrong specifications	0.58	9	0.47	2	0.33	1.00	0.46	7.00
Rework that don't comply with drawings and specifications	0.63	6	0.47	2	0.28	7.00	0.46	7.00
Designer's inexperience in method and sequence of construction	0.60	8	0.37	8	0.33	1.00	0.43	9.00

Group 2. Materials handling and storage factors

The respondents were asked to evaluate causes of construction materials waste arising from materials storage and handling. Table 3 shows that the Relative Importance Index of all the 16 causes of waste evaluated for the respondents.

Table 3: Ranks of Construction Materials Wastage due to Materials Handling and Storage

	Contractor		Consultant		Client		Weighted Avg	
(A): Procurement	**RII**	**R**	**RII**	**R**	**RII**	**R**	**RII**	**R**
Materials Poorly schedule to procurement the materials	0.70	1	0.55	1	0.33	1.00	0.53	1
Over ordering or under ordering due to mistake in quantity surveys	0.57	2	0.47	2	0.28	2.00	0.44	2
Purchased materials that don't comply with specification	0.55	3	0.47	2	0.23	3.00	0.42	3
(B): On site	-		-		-		-	
Poor storage of materials	0.88	1	0.55	1	0.40	1.00	0.61	1
Poor quality of materials	0.88	1	0.55	1	0.40	1.00	0.61	1
Lack of onsite materials control	0.77	3	0.55	1	0.40	1.00	0.57	3
Using excessive quantities of materials more than the required	0.65	6	0.55	1	0.40	1.00	0.53	4
Conversion waste from cutting uneconomical shapes	0.70	4	0.47	5	0.35	5.00	0.51	5
Overproduction/Production of a quantity greater than required or earlier than necessary	0.70	4	0.47	5	0.35	5.00	0.51	5
(C): Handling	-		-		-		-	
Wrong handling of materials	0.88	1	0.73	1	0.47	1.00	0.69	1
Unnecessary material handling	0.83	2	0.73	1	0.47	1.00	0.68	2
Insufficient instructions about handling	0.82	3	0.73	1	0.42	3.00	0.66	3
(D): Storage	-		-		-		-	
Wrong storage of materials	1.00	1	0.55	1	0.47	1.00	0.67	1.00
Inadequate stacking and insufficient storage on site	1.00	1	0.55	1	0.47	1.00	0.67	1.00
Insufficient instructions about storage and stacking	1.00	1	0.55	1	0.47	1.00	0.67	1.00

Inappropriate storage leading to damage or deterioration	0.67	4	0.55	1	0.47	1.00	0.56	4.00

Group 3. Operation On site, Equipment factors

The Relative Importance Index of each of the sub-factors of the operation on site group, which causes construction material waste, is presented in Table 4.

Table 4: Ranks of Construction Materials Wastage due to Operation due to site factors

	Contractor		Consultant		Client		Weighted Average	
(A): On site	RII	R	RII	R	RII	R	RII	R
Choice of wrong construction method	0.88	1	0.45	1	0.40	1	0.58	1
Shortage of manpower (skilled, semiskilled ,unskilled labor)	0.77	2	0.45	1	0.40	1	0.54	2
Poor workmanship	0.72	3	0.45	1	0.40	1.	0.52	3
Using untrained labors	0.72	3	0.45	1	0.40	1	0.52	3
Lack of coordination among crews	0.72	3	0.45	1	0.40	1	0.52	3
Rework due to workers" mistakes	0.70	6	0.45	1	0.35	7	0.50	6
Lack of workers or tradesmen or subcontractors skill	0.65	8	0.45	1	0.40	1	0.50	6
Use of incorrect material, thus requiring replacement	0.68	7	0.45	1	0.35	7	0.49	8

Group 4. Site management and practices factors

The Relative Importance Index each of the sub-factors of the site management and practices group, which causes construction material waste, is presented in Table 5.

Table 5: Ranks of Construction Materials Wastage due to Site Management and Practices

FACTORS	Contractor		Consultant		Client		Weighted Average	
	RII	R	RII	R	RII	R	RII	R
Lack of proper waste management plan and control	0.95	1	0.47	1	0.40	1	0.61	1
Poor project management & Lack of a quality management system aimed at waste minimization	0.95	1	0.47	1	0.40	1	0.61	1-
Lack of strategy to waste minimization and lack of team work	0.95	1	0.47	1	0.40	1	0.61	1
Poor qualification of the contractor's technical staff assigned to the project	0.95	1	0.47	1	0.40	1	0.61	1
Poor provision of information to project participants	0.83	5	0.47	1	0.40	1	0.57	5
Ineffective planning and scheduling of the project by the contractor	0.83	5	0.47	1	0.40	1	0.57	5
Poor management and distribution of labors, materials and equipment's	0.83	5	0.47	1	0.40	1	0.57	5
Shortage of technical professionals in the contractor's organization	0.82	8	0.47	1	0.35	8	0.54	8
Poor coordination and communication between parties involved in the project	0.82	8	0.47	1	0.35	8	0.54	8

Group 5. Site supervision factors

The Relative Importance Index of each of the sub-factors of the site supervisor group, which causes construction material waste, is presented below in Table 6.

Table 6: Ranks of Construction Materials Wastage due to Site Supervisor Factors

Factors	Contractor		Consultant		Client		Weighted Avg	
	RII	**R**	**RII**	**R**	**RII**	**R**	**RII**	**R**
Lack of supervision and delay of Inspections	0.58	1	0.45	1	0.42	1	0.48	
Poor coordination and communication between the consultant engineer, contractor and client	0.58	1	0.45	1	0.42	1	0.48	1.00
Poor qualification of consultant engineer's staff assigned to the project	0.58	1	0.45	1	0.42	1	0.48	1.00

b. Summary Sources and causes of construction materials waste on project

The questionnaire of this study considered 45 factors which cause material waste in construction, and those factors were distributed into five groups as mentioned before, namely, Design and documentation, materials handling and storage, operation, site management practices, and site supervision. Table 7 gives the result of collected data in the second section of the questionnaire, namely, causes of construction materials waste and illustrates the mean and ranking of each group.

Table 7: Weighted Average and Ranking overall Causes of Construction Materials Wastage

Group No.	Factors	Weighted Average all groups	Rank
Group 2	Handling and Storage	0.58	1
Group 4	Site Management	0.58	2
Group 3	Operation	0.52	3
Group 1	Design and documentation	0.49	4
Group 5	Site supervision	0.48	5

c. Causes of key construction material wastage on Ajima chacha sites

The results shows that the key materials which are wasted on construction sites are; concrete, reinforcement steel, cement, fine, and coarse aggregate are contributed to the generation of waste on construction sites.

a. Fine Aggregate

The RII and rank of each factor of the sand waste are presented in Table 8 in descending order. The major cause can be pointed out for sand waste is excessive consumption of sand that results from insufficient information about the used quantities and poor supervision.

Table 8: Relative Importance Index and Ranking of Sand Wastage on Construction Sites

	Contractor		Consultant		Client		Weighted Average	
	RII	R	RII	R	RII	R	RII	R
Poor storage	0.93	2	0.65	1	0.47	1	0.68	1
under quality	1.00	1	0.37	3	0.33	2	0.57	2
Excessive consumption of sand	0.58	3	0.47	2	0.28	3	0.44	3
Theft of sand	0.27	4	0.37	3	0.23	4	0.29	4
Damage the remained quantities in the place work	0.23	5	0.37	3	0.23	4	0.28	5

b. Cement

Analyzing the waste of cement is relatively complex because this material is used as a component of mortar and wet trades which include block walling, plastering, floor screeds, internal and external finishing. The Relative Importance index and rank of each factor of the cement waste are presented in Table 9.

Table 9: Relative Importance Index and ranking of cement wastage on construction sites.

	Contractor		Consultant		Client		Weighted Average	
	RII	R	RII	R	RII	R	RII	R
Improper storage	0.82	1	0.37	1	0.33	1	0.51	1
Loading the cement manually in the mixer using inadequate equipment's and tools	0.70	2	0.37	1	0.33	1	0.47	2
Excessive quantities during mixing more than the required	0.70	2	0.37	1	0.33	1	0.47	2
Damage the fall mortar during plastering	0.70	2	0.37	1	0.33	1	0.47	2
Inappropriate way of transportation & Excessive consumption of mortar in joints	0.68	5	0.37	1	0.28	5	0.44	5
Mixing of quantities greater than the required and Mixing in unsuitable places	0.68	5	0.37	1	0.28	5	0.44	5

c. Coarse Aggregate

The mean and rank of each factor of the course aggregate waste are presented in Table 10.

Table 10: Relative Importance Index and ranking of course aggregate wastage on construction sites

	Contractor		Consultant		Client		Weighted Average	
	RII	R	RII	R	RII	R	RII	R
Improper handling	0.72	1	0.47	1	0.33	1	0.51	1
Excessive quantities during mixing	0.52	2	0.37	2	0.28	2	0.39	2

Mixing quantities are greater than the required	0.52	2	0.37	2	0.28	2	0.39	2
Far distance between the place of mixing and casting	0.52	2	0.37	2	0.28	2	0.39	2

d. Steel reinforcement

Dominating use of steel reinforcement in construction sites is relatively difficult because it is cumbersome to handle due to its weight and shape. But this reason has one of the lowest waste indices among all factors, which cause the waste of steel reinforcement. Most companies in Ethiopia use a table to calculate the weights of required bars. However, most construction companies do not have a table to calculate the weight of surplus bars and short unusable pieces. The mean and rank of each factor of the steel reinforcement waste are presented in Table 11.

Table 11: Relative importance Index and ranking of steel reinforcement wastage on construction sites

	Contractor		**Consultant**		**Client**		**Weighted Average**	
	RII	**R**	**RII**	**R**	**RII**	**R**	**RII**	**R**
Unnecessary replacement of some bars by others of large diameter	0.75	1	0.37	1	0.33	1	0.48	1
Poor handling because its cumbersome to handle due to weight and shape	0.75	1	0.37	1	0.33	1	0.48	1
Structure design was poor in terms of standardization and detailing & Damage during storage and rusting	0.73	3	0.37	1	0.28	3	0.46	3
No optimized cutting of bars	0.68	4	0.37	1	0.28	3	0.44	4

e. Timber formwork

Timber possesses several advantages, it is relatively inexpensive compared to other materials, light in weight and easy to handle, and it can be shaped for producing any distinct forms of concrete elements. However, its relatively low durability and reusability make it a material of high wastage. The mean and rank of each factor of the timber formwork waste are presented in Table 12.

Table 12: Relative Importance Index and ranking of Timber formwork wastage on construction sites

	Contractor		**Consultant**		**Client**		**Weighted Average**	
Factors	**RII**	**R**	**RII**	**R**	**RII**	**R**	**RII**	**R**
Improper storage	0.53	2	0.37	1	0.40	1	0.43	1
Non optimized cutting of timber & pole	0.53	2	0.37	1	0.40	1	0.43	1
Cutting the longer timber although the required are found	0.53	2	0.37	1	0.40	1	0.43	1
Using for other purposes	0.57	1	0.37	1	0.35	5	0.43	4
Use of low quality timber & wood pole	0.42	5	0.37	1	0.40	1	0.39	5
Cutting for internal finishing and fittings	0.40	6	0.37	1	0.35	5	0.37	6

d. Storage and Handling of Construction materials onsite

In this part, respondents were asked to assess materials waste in construction projects. The results exposed that the key materials, which are wasted most on construction sites, are concrete, cement, aggregate, sand reinforcement steel and timber.

a. Steel reinforcement

Controlling the use of steel reinforcement in project sites is relatively difficult because it is cumbersome to handle due to its weight and shape. The main causes of wastage of steel are as a result of cutting, damages during storage and design change. Fig. 4 wastage of steel bar due to non-optimized cutting of bars and design change

Figure 4: Wastage of Steel Reinforcement due to improper cutting of bars and design change

The storage of concrete making materials on construction sites is a major problem. Some of these materials are not stored appropriately resulting in the severe wastage of materials on site. Coarse and fine aggregates and cement should be properly stored, batched, and handled to maintain the quality of the resulting concrete. This section presents photographs of how key materials are wasted on construction sites as a result of storage and recommends appropriate ways of storing these materials to reduce their levels of wastage on construction sites.

Figure 5: Improper Handling of Sand onsite

a. Fine aggregates and stone through storage and handling

If the aggregate is not properly stored, it will limit the strength of the concrete work on a project, it could also affect the durability and structural performance of the masonry work. Aggregates should be stored where they will not have direct contact with the lateritic soil, which may reduce the quality of the mortar.

Figure 6: Poor Storage of Stone on site

Contamination of materials by deleterious substances such as, trucks track clay and mud onto aggregate, Segregation of aggregate and degradation of aggregate are common stockpiling problems.

Figure 7: Poor handling of coarse aggregate onsite

To minimize the wastage of aggregates through storage and handling, aggregates should be stored in separate bunkers when many gradations and types of aggregate are required in small quantities for relatively low-production operations. Otherwise, it should be stored in open stockpiles.

Figure 8: Good handling of sand and coarse aggregate on project site

b. Batching and measurement of concrete making materials

The batching and measurement of concrete making materials most of the time lead to wastage of these materials on construction sites. Some of the wastages from batching involve

- ✓ Aggregate segregation
- ✓ Varying moisture content, addition of much water, resulting in reduced concrete strength and increased shrinkage

To avoid wasting the aggregates, proper equipment should be used. To assist in minimizing the wastage of concrete making materials resulting from batching, it is recommended that the following procedures be adhered to.

- ✓ Mixer blades should be maintained.
- ✓ Separate aggregate basket for each size of coarse aggregate should be used.
- ✓ Bins should be capable of shutting off material with precision.
- ✓ Mixer should not be loaded above rated capacity.
- ✓ Mixer should be operated at recommended speed.

c. Wastage arising from mixing and transportation of concrete on site

Thorough mixing is essential for the production of uniform quality concrete. Therefore, equipment and methods should be capable of effectively mixing concrete materials containing the largest specified aggregate to produce uniform mixtures of the lowest slump practical for the work. The method used to transport concrete depends on which one is the lowest in cost and easiest for the job size. Some ways to transport concrete include a concrete truck, a concrete pump, a crane and bucket. On small jobs a wheelbarrow is the easiest way to transport concrete. Always transport concrete as little as possible to reduce problems of segregation and wastage. Concrete should be transported from the mixer to the place of casting as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients and maintain the required workability.

d. Wastage of cement through storage and handling

Analyzing the waste of cement is relatively complex because of this material is used as a component of mortar and cast-in-place concrete in several different processes, such as plastering and floor screed. The effects of poor storage of cement and handling result in cracks.

Figure 9: Wastage of cement due to poor handling, Lack of control & poor storage

e. Methods of storing cement to minimize wastage

Portland cement that is kept dry retains its quality indefinitely. Portland cement stored in contact with moisture sets more slowly and has less strength than dry Portland cement. A warehouse or shed used to store cement should be as air-dry as possible. All cracks and openings should be closed. Cement bags should not be stored on damp floors. Bags should be stacked close together to reduce air circulation, but they should not be stacked against outside walls. Bags to be stored for long periods should be covered with tarpaulins or other waterproof covering. Standard strength tests or loss on ignition tests should be made whenever the quality of the cement is doubtful. Bulk cement is usually stored in waterproof bins. Ordinarily, it does not remain in storage very long but it can be stored for a relatively long time without deterioration.

Figure 10: Recommended ways of storing cement on construction site

e. Impacts of material wastage on construction sites and environment

Construction waste has become a global issue facing by practitioners and researchers around the world. Waste can affect the success of construction projects significantly. More specifically, it has major impact on construction cost, construction time and productivity and sustainability aspects. The highest environmental impact of construction materials waste is believed in terms of contamination. Construction sites generate high levels of dust typically from concrete, cement, wood and stone and this can cover large areas over a long period.

f. A future framework for minimizing materials wastage on construction sites

A successful project requires careful planning, organization and control throughout the project to achieve the correct result for the client. For the contractor, good planning, organization and control are essential in order to achieve a timely and satisfactory outcome for the client, and to ensure a financial profit. To ensure the successful implementation of construction projects there should be an effective teamwork between all parties.

Managing a construction project depends on how parties in a construction project interpret the construction process.

Lack of standardization can be viewed as one of the reasons for the inefficiency of the construction sector. There is also the need for managers to maintain personal discipline, direct and coach others to keep within standards and procedures and always react to off standard and off target situations with immediate investigation. In addition, standardized construction elements should be promoted to reduce the amount of materials wasted on construction sites.

IV. CONCLUSION

The study has identified materials storage and handling, operational factors, design and documentation factors and procurement factors as the main sources of material waste on construction sites in Ajima Chacha mega irrigation project. The study also identified late client requirement, errors by workers, noncomplying purchased products with specification and lack of onsite materials management are the main causes of materials waste. Fine aggregate, cement, coarse aggregate, reinforcement bar and timber are the four key materials with high levels of wastage on Ajima Chacha mega irrigation project construction sites. From the results of the analysis of respondents' responses, the contractor was the most predominant originating agent of poor construction management. Based on research findings, the following conclusions are set;

1. Due to poor production and non-conforming problems of the sand and aggregates delivered to the construction site, the supply is not consistent and there is a high degree of non-uniformity of supplies.
2. Coordination of the project participants is key to minimize materials wastage for successful completion of the project within the time frame and cost.
3. Contractors should reduce waste during the construction through implementing good strategies for resource management.
4. Installing stockpiling facilities near the site can significantly reduce unnecessary material waste.
5. Employing experienced labor and supervisors and implementing training programs are important in enhancing waste management.

Since this research is limited to only Ajima Chacha mega irrigation project, further research should be conducted to identify the cause of materials wastage in other construction projects in Ethiopia.

Authors contribution

Shumet Getahun Reda; Editing, Analysis, Manuscript Mohammed Adam; Writing, methodology

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CONSENT FOR PUBLICATION

Informed consent was obtained from all subjects involved in the study

Data Availability Statement

All materials and data are available in the hands of the authors

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

Appendix A

Questionnaires

The objective of this survey is to study the practice of construction Materials waste management on Ajima chacha mega irrigation project in North Shewa and the causes of materials waste on construction sites and to rank highly wasted material from principal construction material. Hence, your value response sincerely appreciated.

Section A: Respondents Profile

1. Which of the following best describes your company?
a. Contractor b. Consultant c. Client
2. Is your field of study in engineering? Civil Engineer, Construction Technology, Architecture etc. a. Yes b. No
3. If your answer is "Yes" for the above question, how long have you worked in the construction industry (years)? a. Less than 2 b. 2 to 5 c.5 to 10 d.10 to 15 e. > 15
4. How long have you worked for your present company in years?
a. Less than 2 b. 2 to 5 c. 5 to 10 d. 10 to 15 e. > 15
5. What is your current position in your organization?
a. Contract Administrator b. Project Manager c. Project Engineer

d. Site Engineer e. Office Engineer f. Client representative g. General Manager i. Other.
6. How long have you been in your present position?
a. Less than two year's b. 2 to 5 year's c. 5 to 10 year's d. > 10 years

Section B: System

1. Did you know about construction material waste management system? a. Yes b. No 2. Did you know how construction material waste minimization? a. Yes b. No
3. How good construction material handling management system instructed?
a. In written form b. orally c. Sometimes Orally and in Writing d. By punishment for their inappropriate work

Section C: System

1. What are the major impacts of construction materials waste on construction site?
2. Which construction parties beneficial in managing and minimizing wastage of construction materials on building construction? And how?
3. Who should take action to reduce construction materials waste?
4. What are future Framework for Minimizing Materials Wastage on Construction Sites? Specify others (if any)

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