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Critical FactorsAffecting Labour Productivity InConstruction Projects: Case Study Of South Gujarat Region Of India

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Abstract*— Labour productivity is one of the least studied areas within the construction industry. Productivity improvements achieve higher cost savings with minimal investment. Due to the fact that profit margins are small on construction projects, cost savings associated with productivity are crucial to becoming a successful contractor. The chief setback to improving labor productivity is measured labor productivity. The main objective of this study is to find critical factors affecting labour productivity. A survey was carried out in south Gujarat region cities , oncivil contractors. Total 51 feedbacks were analyzed through the Analytic hierarchy process(AHP) and Relative Importance Index(RII) techniques.Five most crucial factorsin descending order from RII Technique areDelay in payments, Skill Of Labour, Clarity Of Technical Specification,Shortage Of Materials, and Motivation of Labour. According to AHP Technique first 5 crucial factors in descending order are High/Low Temperature, Rain, High Wind, Motivation of Labour, andPhysical Fatigue. Contractors shall act on these factors to improve labour productivityin construction projects.

***Keywords*—labour productivity, Construction contractor, India, Relative importance index,Analytic Hierarchy Process, rank.**

I. INTRODUCTION

Construction labor productivity has become big problem in construction industry. In most countries,labour cost comprises 30 to 50% of the overall project's cost(Yates and Guhathakurta 1993; McTague and Jergeas 2002), and thus is regarded as a true reflection of the economic success of the operation. Horner et al. (1989) indicated that a 10% increase in construction labour productivity would yield annual savings of approximately billion to the British economy; a similar conclusionwas echoed by Stoekel and Quirke (1992). Because construction is a labour-intensive industry, the significance of this effect not only justifies the concern over its labour productivity, but it can also be argued that labour power is the only productive resource, hence construction productivity is mainly dependent upon human effort and performance. There are many challengesthat are faced by construction industry in India, but one of the important challenge is labour productivity in construction. Every project hassome difficulty in construction like material, money, tools and local contractor's construction cost.

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Looking to the current scenario of continuous downfall ofconstruction labour productivity, it is highly necessary to identify the factors which affect it and then work out the critical ones out of the available factors.

II. OBJECTIVE OF STUDY

The main objectives of this study include the following:

- To identify the main factors associated with loss of productivity in construction projects of the South Gujarat region of India.
- To give the ranking to thesefactors by AHP (analytical hierarchy process) and RII (relative importance index) techniques.

III. LITERATURE REVIEW

A number of studies have been carried out to determine the factors affecting labour productivity in construction projects.

The word productivity was invented in1766 when it was first mentioned in an article by Quesnay ,Veggi (1987). More than a one century later 1883, the productivity is defined as "faculty to produce"bythe changes of time the modification was made in the definition "the relationship between output and means employed to produce that output"was developed.

The American association of cost engineers, moreover, define the productivity as a "relative measure of labour efficiency, either good or bad, when compared to a stabilized base or norm"(Salmon et al. 2000) while Arditindmochtar (2000) regard to productivity as "the ratio between total output expressed in dollars and total inputs expressed in dollars as well"honer and duff (2001)expressed productivity as "how much is produced per unit input"

In 2006 M.R. Abdul Kadir, W.P. Lee, M.S. Jaafar, S.M. Sapuan and A.A.A. Ali from Malaysia did survey of 100 respondents consisting of 70 contractors,11 developers and 19 consultants.They used relative importance index (RII) method to carry out the ranking of criteria affecting labour productivity as per their study critical factors were :(1) technology, (2) human/labour,(3)management,and(4)external.

In 2012,Abdulaziz M. Jarkas, and Camille G. Bitarcarried out a survey in Kuwait.The objective of this research was to identify and rank the relative importance of factors perceived to affect labor productivity on construction sites.

To achieve this objective, a statistically representative sample of the contractors was invited to participate in questionnaire survey, comprising 45 productivity factors. As per their finding important factor were: (1)Clarity of technical specifications, (2) Extent of variation/change orders during execution, (3) Coordination level among various design disciplines

In 2013Khaled, Mahmoud El-Gohary andRemon, Fayek Aziz from Egypt carried out the survey.The questionnaire comprised thirty productivity factors where they classified them under the following three primary categories: (a) human/labor; (b) industrial; (c) management. They used relative importance index method. This index was computed for every factor for each specific year of the participants' experience.

In 2013Wen Yi1and Albert P.C. Chan carried out the study of a systematic review on labor productivity in the construction industry. The aims of this review were to investigate the state of the art and trends in CLP (critical labour productivity) research, and to identify key research areas. Above researches are carried out in countries other than India. Such study is required to be carried out in India. The present study aims to carry out study of labor productivity factors in Indian context. The scope of the study is limited to the south Gujarat region of India.

IV. RESEARCH METHODOLOGY

The relevant data for this investigation were collected by a structured, close-ended questionnaire survey. On the basis of related previous studies on labor productivity and the input of local industry experts, professionals, and practitioners, 27 factors were identified which are having an influence onconstruction labor productivity in the Gujarat state of India..

The target population included civil engineering and building construction firms that are classified by the contractors. Survey was having a target population of 3 cities :Surat,Navsari, and Valsad in south Gujarat region of India.

To obtain statistically representative sample size of the population following equation was used :

$$n = \frac{m}{1 + \frac{(m-1)}{N}}$$

Where n, m and N = the sample size of limited, unlimited available population, respectively. m is estimated by following Equation:

$$\mathrm{m} = \frac{\mathrm{z}^2 * \mathrm{p} * (1 - \mathrm{p})}{\mathrm{e}^2}$$

Where z=the statistic value for the confidence level used, i.e, 1.96, and 1.645 for 95% and 90% confidence level respectively; p=the value of the population that estimated and e=the sampling error to be estimated.Because the value of p is unknown sincich et al. (2002) suggest the value 0.50 to be used in sample size.

$$m = \frac{1.645^2 * 0.50 * (1 - 0.50)}{(0.05)^2}$$

$$\approx 271$$

Here confidence level is taken as 90%.Accordingly,for the total number of classified contractors, the sample size is 152.

$$n = \frac{271}{1 + \frac{(271-1)}{344}}$$

$$\approx 152$$

This study received total 51 responses which are 30% of the required sample size.The 27 factors surveyed into four groups: (1) technology, (2) human/labour, (3) management, and (4) external.

The research methodology contains two phases. The first phase included a literature search and interviews. The literature review was conducted through books, conference proceedings, internet and international project management journals. As the outcome of this phase, 27 factors affecting labour productivity for residential construction projects were identified. These factors were categorized into four main groups as: (1) technological group. (2) Human/labor group (3) management group& (4) external group. The framework of the factors is given in Table 1.

Table 1: Framework of factors affecting construction labour productivity

NO	CRITERIA	SUB CRITERIA
1	TECHNOLOG-ICAL	
1A		Clarity of technical specification
1B		The extent of variation/change order During execution
1C		Coordination level among design disciplines
1D		Design complexity level
1E		Rework
1F		Site lay out
1G		Inspection delay/stringent by the engineer
1H		Site restricted access
2	HUMAN/LAB-OUR	
2A		Motivation of labour
2B		Skill of labour
2C		Physical fatigue
2D		A shortage of experienced labour
3	MANAGEM-ENT	TYPE-A (MANAGEMENT)
3A1		Construction managers lack of leadership
3A2		Lack of labour supervision
3A3		Working over time
3A4		Crew size and composition
3A5		Unsuitability of storage location
3A6		Accidents as a result of poor site safety programme
		TYPE-B (MATERIAL)
3B1		Proportion of work subcontracted
3B2		Unrealistic scheduling and expectation of labour performance
3B3		Shortage of materials

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3B4		Construction method
3B5		Payment delay
4	EXTERNAL	
4A		High/low temperature
4B		High humidity
4C		High wind
4D		Rain

The second phase includes preparation of two types of questionnaire based on two different approaches used. ForAHP (Analytic Hierarchy Process) technique questionnaire include comparison of factors on 1 to 9 scale.The present study suggests two different techniques for ranking of factors affecting on labour productivity. In first technique Relative Importance Index (RII) of each factor affecting on labour productivity can be calculated and in second techniqueAnalytic Hierarchy Process was used. Survey questionnaire based on these techniques are given in Appendix 1 and 2.

A. *Data analysis approaches*

Following is the data analysis approach :

Relative Importance Index technique: Relative Importance Index method helps to determine the relative importance of the various factors affecting on labour productivity. The four-point scale ranging from 1 (less important) to 4 (extremely important) is adopted and it is transformed to relative importance indices (RII) for each factor as follows:

$$\text{RII (\%)} = \frac{4(n4)+3(n3)+2(n2)+1\,(n1)}{4\,(n1+n2+n3+n4)} * 100$$

Where: n1, n2, n3, and n4, = the number of respondents who selected: 1, for no effect; 2, for little effect; 3, for moderate effect; 4, for strong effect;.

n is the weighting given to each factor by the respondents (ranging from 1 to 4), A is the highest weight (i.e. 4 in this case). The RII value had a range from 0 to 4 (0 not inclusive), Higher the value of RII, more important was the factors affecting on labour productivity.

The RII was used to rank (R) the different factors affecting on labour productivity. These rankings made it possible to cross-compare the relative importance of the factors as perceived by respondents (i.e.Contractors). Each individual factors's RII perceived by all respondents should be used to assess the general and overall rankings in order to give an overall picture of the labour productivity.

Analytic Hierarchy Process : In this technique, For each factor questions should be askedIt has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education.A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

Analytic Hierarchy Process [10] is a multipleCriteria decision-making tool. This is an Eigenvalue approach to the pairwise comparisons. It alsoprovides a methodology to calibrate the numeric scale for the measurement of quantitative as wellas qualitative performances. The scale ranges from1/9 for _least valued than_, at 1 for _equal_, and to 9for _absolutely more important than_ covering theentire spectrum of the comparison. Some key and basic steps involved in this methodologyare: 1. State the problem, 2. Broaden the objectives of the problem or consider allfactors, objectives and its outcome. 3. Identify the criteria that influence the behavior. 4. Structure the problem in a hierarchy of different levels constituting goal, criteria, sub-criteriaand alternatives. 5. Compare each element in the corresponding level and calibrate them on the numerical scale. This requires an (n_1) /2 comparisons, where n is the number of elements with the considerations that diagonal elements are equal or _1_ and the other elements will simply be the reciprocals of the earlier comparisons. 6. Perform calculations to find the maximumEigenvalue, consistency index CI, consistencyratio CR, and normalized values for each criteria/alternative. 7. If the maximum Eigenvalue, CI, and CR are satisfactory then the decision is taken based onhe normalized values; else the procedure isrepeated till these values lie in a desired range. AHP helps to incorporate a group consensus. Generally this consists of a questionnaire for comparisonof each element and geometric mean to arrive at a final solution. The hierarchy method used in AHP has various advantages (see [10]).

V. RESULTS AND DISCUSSION

From AHP &RII techniques ranking of factors which affects labour productivity were worked out. Following table gives this ranking.

Table 2: Ranking of factors affecting labour productivity by AHP & RII Technique

NO	CRITERIA	SUB CRITERIA	AHP RANK	RII RANK
1	TECHNOLOGICAL			
		Clarity of technical specification	10	3
		The extent of variation/change order During execution	16	15
		Coordination level among design disciplines	13	21
		Design complexity level	14	12
		Rework	15	13
		Site lay out	9	18
		Inspection delay/stringent by the engineer	12	8
		Site restricted access	11	14
2	HUMAN/LABOUR			
		Motivation of labour	4	5
		Skill of labour	8	2

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		Physical fatigue	5	7
		A shortage of experienced labour	6	9
3	MANAGEMENT	TYPE A (MANAGEMENT)		
		Construction managers lack of leadership	21	10
		Lack of labour supervision	27	23
		Working over time	26	25
		Crew size and composition	24	24
		Unsuitability of storage location	25	27
		Accidents as a result of poor site safety programme	22	17
		TYPE B (MATERIAL)		
		Proportion of work subcontracted	17	20
		Unrealistic schedules and expectation of labour performance	23	11
		Shortage of materials	19	4
		Construction method	20	6
		Payment delay	18	1
4	EXTERNAL			
		High/low temperature	1	16
		High humidity	7	22
		High wind	3	26
		Rain	2	19

VI. CONCLUSION

From the present study, total 27 factors were identified which affectslabor productivity in construction projects. 51 feedbacks from various civil contractors were collected to identify critical factors by two techniques : AHP & RII.RII Technique gives first 5 crucial factors as: (1) Payment Delay, (2) Skill Of Labour, (3) Clarity Of Technical Specification, (4) Shortage Of Materials, (5) Motivation Of Labour. AHP Technique gives first 5 crucial factors as: (1) High/Low Temperature, (2) Rain, (3) High Wind, (4) Motivation Of Labour, (5) Physical fatigue. Finding from this study reveals that there is a contradiction in critical factors ranking by two techniques. RII technique gave first rank to delay in payments while AHP technique gave first rank to high/low temperature. Contractors should act on these factors to improve labour productivity which ultimately can help to get higher profits from the projects.

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APPENDIX I

MAIN QUESTIONNAIRE (FOR FINDING RELATIVE IMPORTANCE INDEX)

Please indicate by ticking the appropriate column the relative importance of each of the following .You have to tick mark (√) in any one column for each row of factor according to your experience.

Factors affecting on labour productivity

No.	*Group*	*Factors affecting on labour productivity*	*Very important*	*Important*	*Somewhat important*	*Less important*
1	Technological	Clarity of technical specification				
2		The extent of variation/change order During execution				
3		Coordination level among design disciplines				
4		Design complexity level				
5		Rework				
6		Site lay out				
7		Inspection delay/stringent by the engineer				
8		Site restricted access				
9	Human/labour	Motivation of labour				
10		Skill of labour				
11		Physical fatigue				
12		A shortage of experienced labour				
13	Management	Type A (labour management)				
14		Construction managers lack of leadership				
15		Lack of labour supervision				
16		Working over time				
17		Crew size and composition				
18		Unsuitability of storage location				
19		Accidents as a result of poor site safety program				
20		Type B (Material management)				
21		Proportion of work subcontracted				
22		Unrealistic scheduling and expectation of labour performance				
23		Shortage of materials				
24		Construction method				
25		Payment delay				
26	External	High/low temperature				
27		High humidity				

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28		High wind				
29		Rain				

APPENDIX II

MAIN QUESTIONNAIRE (FOR ANALYTIC HIERARCHY PROCESS)

While, doing the comparison, please use 1-9 scale and **circle only one digit in one row.**
Please mark red Colour on selected digit if the reply is to be sent through e-mail.

NOTE: Please give feedback with reference to your site conditions of your site only.

1. Amongst 4 factors, compare their relative importance for a labour productivity:

Technological												Management				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Technological												Human/labour				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Technological												External				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Management												Human/labour				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Management												External				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Human/labour												External				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

2. **For human/labour group**, compare various categories for a **factor affecting on labour productivity**.

Motivation												Skill of labour				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Motivation												Physical fatigue				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Motivation												Shortage of experienced labour				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Skill of labour												Physical fatigue				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Skill of labour												Shortage of experienced labour				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Physical fatigue												Shortage of experienced labour				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

3. For Technological group, compare following parameters based on their importance for a factor affecting on labour productivity.

Clarity of technical specification												The extent of variation/change order During execution				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Clarity of technical specification												Coordination level among design Disciplines				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Clarity of technical specification												Design complexity level				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Clarity of technical specification												Rework				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Clarity of technical specification												Site layout				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Clarity of technical specification												Inspection delay /stringent by Engineer				
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Clarity of technical specification — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The extent of variation /change order During execution — Coordination level among design disciplines

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The extent of variation /change order During execution — Design complexity level

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The extent of variation /change order During execution — Rework

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The extent of variation /change order During execution — Site layout

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The extent of variation /change order During execution — Inspection delay/stringent by Engineer

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The extent of variation /change order During execution — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Coordination level among design Disciplines — Design complexity level

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Coordination level among design Disciplines — Rework

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Coordination level among design Disciplines — Site lay out

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Coordination level among design Disciplines — Inspection delay/stringent by engineer

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Coordination level among design Disciplines — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Design complexity level — Rework

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Design complexity level — Site layout

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Design complexity level — Inspection delay/stringent by the engineer

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Design complexity level — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Rework — Site layout

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Rework — Inspection delay/stringent by the engineer

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Rework — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Site layout — Inspection delay/stringent by the engineer

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Site layout — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Inspection delay/stringent by engineer — Site restricted access

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

4. To **Management group** , please compare following parameters for a labour Productivity.

Material Group — Management Group

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

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Type A (labour management group)

Construction managers lack of Leadership — Lack of labour supervision

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Construction managers lack of Leadership — Working over time

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Construction managers lack of Leadership — Crew size and composition

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Construction managers lack of Leadership — Unsuitability of storage location

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Construction managers lack of Leadership — Accidents as a result of poor site safety program

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Lack of labour supervision — Working over time

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Lack of labour supervision — Crew size and composition

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Lack of labour supervision — Unsuitability of storage location

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Lack of labour supervision — Accidents as a result of poor site safety Program

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Working overtime — Crew size and composition

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Working overtime — Unsuitability of storage location

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Working overtime — Accidents as a result of poor site safety Program

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Crew size and composition — Unsuitability of storage location

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Crew size and composition — Accidents as a result of poor site safety Program

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Unsuitability of storage location — Accidents as a result of poor site safety Program

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

- Type B (material management)

Proportion of work subcontracted — Unrealistic scheduling and expectation of labour performance

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Proportion of work subcontracted — Shortage of materials

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Proportion of work subcontracted — Construction method

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Proportion of work subcontracted — Payment delay

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Unrealistic scheduling and expectation — Shortage of materials — of labour performance

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Unrealistic scheduling and expectation — Construction method — of labour performance

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Unrealistic scheduling and expectation — Payment delay — Of labour performance

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

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Shortage of materials									Construction method								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

Shortage of materials									Payment delay								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

Construction method									Payment delay								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

5. For **External**, compare following parameters for labour productivity based on their importance.

High/low temperature									High humidity								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

High/low temperature									High wind								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

High/low temperature									Rain								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

High humidity									High wind								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

High humidity									Rain								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

High wind									Rain								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	

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