 ISBN: 978-984-33-4363-5

Activities planning and work scheduling of a water supply master plan project in Bangladesh

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ABSTRACT: Preparation of a water supply master plan is a complex task for planners, because multiple interconnected activities require proper activities planning and work scheduling to accomplish the project task within the stipulated time. Department of Public Health Engineering (DPHE) of the Government of Bangladesh (GOB) has taken up a project in 2010 which includes preparation of water supply master plans of 148 Paurashavas of Bangladesh along with other components of urban utilities. In order to carry out the project smoothly, the preparation of water supply master plan is divided into some dependent and independent activities and these activities are allocated to different teams. The teams are formed to perform specific tasks and synchronized to avoid conflict regarding timely data support for other teams. Program Evaluation and Review Technique (PERT) with the conjunction of Critical Path Method (CPM) are used to perform the planning with Microsoft Project 2007 software.

1 INTRODUCTION

A water supply master plan preparation project includes various dependent and independent activities; which are interconnected with each other for data exchange and feedback regarding data support. An organized activities planning and time scheduling, contributing to total project planning are matters of paramount interest in such projects, especially in case of a long span water supply scheme serving a large population group.

In 2010, the Department of Public Health Engineering of the Government of Bangladesh (GOB) has taken up the country's biggest water supply master plan preparation project ever- "Groundwater Management and TPP for Survey, Investigation, and Feasibility Study in Upazila and Growth Center level Paurashavas having no Piped Water Supply System". The project is very relevant to the policy of GOB-"all necessary means and measures will be taken to manage water resources of the country in a comprehensive, integrated and equitable manner (National Water Policy 1999)". Institute of Water Modelling (IWM) has been employed in the project to perform the assignment-"Mathematical Modelling for Safe Drinking Water Source Identification". The task is enormous, in terms of the project duration, scope of work and span around the country. Hence, adoption of the modern project planning techniques has become indispensable to perform the project efficiently.
The project is divided into 4 distinct phases; 2 phases have already elapsed. Based on the experience of the former phases, the planning of phase-III has been done. Though the project has various components, the scope of this paper focuses mostly on water distribution network modelling.

Project planning is part of project management, which relates to the use of schedules such as Gantt charts to plan and subsequently report progress within the project environment (Kerzner 2003). Initially, the project scope is defined and the appropriate methods for completing the project are determined. Following this step, the durations for the various tasks necessary to complete the work are listed and grouped into a work breakdown structure. The logical dependencies between tasks are defined using an activity network diagram that enables identification of the critical path. Float or slack time in the schedule can be calculated using project management software (Thayer & Yourdon 2000). Combination of classic and modern project planning techniques like Gantt chart, PERT, CPM etc. are used to prepare an efficient and effective activities plan as well as time schedule.

2 ACTIVITIES OF THE PROJECT

2.1 *Social impact assessment survey*

Social impact assessment includes the processes of analyzing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions. Its primary purpose is to bring about a more sustainable and equitable biophysical and human environment (Vanclay 2003). Determination of the baselines conditions of each Pourashava is the prerequisite for SIA which include the investigation of- (a) population characteristics, (b) community and institutional structures, (c) political and social resources, (d) individual and family changes and (e) community resources. Therefore, the required demographic data and dwelling information for the future projection of population and dwelling characteristics can be derived from the baseline study. This type of survey activity is independent of other activities regarding the project and can be done in less time with the inclusion of more manpower in the field. However, optimum manpower should be employed so that the survey cost and time are minimal. Baseline survey of a Paurashava is expected to perform in 7 to 12 working days to avoid hampering of other dependent project activities.

2.2 *Topographic survey*

Topographic survey provides the major information required for the water supply master plan preparation. All the engineering designs and modeling activities of the project are directly dependent on this activity. Topographic survey include alignment survey, physical feature survey, land level survey, land use survey etc. In addition to the scope of topographic survey, water level and discharge measurement are also carried out to fulfill the project requirement. Unlike SIA baseline survey, inclusion of manpower in topographic survey depends on the quantity of survey instruments, some of which are costly and are not affordable in large numbers inside the project scope. Depending on the size of the Paurashava, it can be surveyed in 15 to 25 working days using optimum number of resources. Though this activity is not dependent to other activities but can be hampered due to adverse climate and cropping pattern of the Paurashava area.

2.3 *GIS based mapping*

Geographic Information System (GIS) is a strong tool to incorporate topographic survey outputs in digital format. It creates a database in the form of digital maps which are further used by the modeling teams. Major outputs of GIS based mapping are- (a) physical feature map, (b) land use map, (c) contour map and (d) digital elevation model (DEM). GIS team needs 4 to 7 working days to produce maps after getting survey data from topographic survey team. This activity is directly dependent on topographic survey.

2.4 *Surface water modeling*

Due to environmental consideration, surface water is a priority in any water supply scheme in Bangladesh. Surface water modeling includes surface water availability analysis, dependable flow analysis, surface water quality analysis and reporting. This activity depends on water level & discharge measurement survey and GIS based mapping. In 15 to 20 working days, surface water modeling can be done.

2.5 *Groundwater modeling*

The major tasks of groundwater modeling are- lithological characterization and aquifer delineation, water balance analysis, water resource assessment, water quality assessment and reporting. This activity depends on GIS based mapping and other secondary and primary groundwater level data and pumping test data. Like surface water modeling, groundwater modeling also requires 15 to 20 working days.

2.6 *Water distribution network modeling*

Water distribution network modeling (WDNM) is the major activity of water supply master plan preparation. This activity is entirely dependent on other prior activities for data support and model development. WDNM includes the following sub-activities:

i. Data input
ii. Population projection
iii. Water demand assessment

iv. Digitization of pipe network and model building
v. Modelling, calibration & validation
vi. Reporting and data transfer

For the ease of planning and work scheduling, the aforesaid sub-activities are programmed as individual activities in project planning.

3 PLANNING FOR A SINGLE PAURASHAVA

3.1 *Data exchange*

Topographic survey and Social Impact Assessment (SIA) survey are independent activities and hence corresponding teams do not require any data support from other teams. However, GIS team start map production with the required topographic data supplied by the topographic survey team. GIS based maps are the key components for rest of the teams work mobilization. Groundwater Modelling (GWM) team, Surface Water Modelling (SWM) team and Water Distribution Network Modelling (WDNM) team utilize the digital format of the maps for spatial data input. WDNM team gets demographic data as non spatial data input from SIA team. GWM team and SWM team explore the potential water source and deliver the information to WDNM team. Exploiting the spatial and non spatial data support along with the source decision, WDNM team builds the pipe network model supplies the digital pipe layout to GIS team for production maps. After production of pipe network maps, GIS team delivers the maps to the WDNM team again. WDNM team, GWM team and SWM team convey their individual reports and maps to the report compilation unit for the preparation of final report.

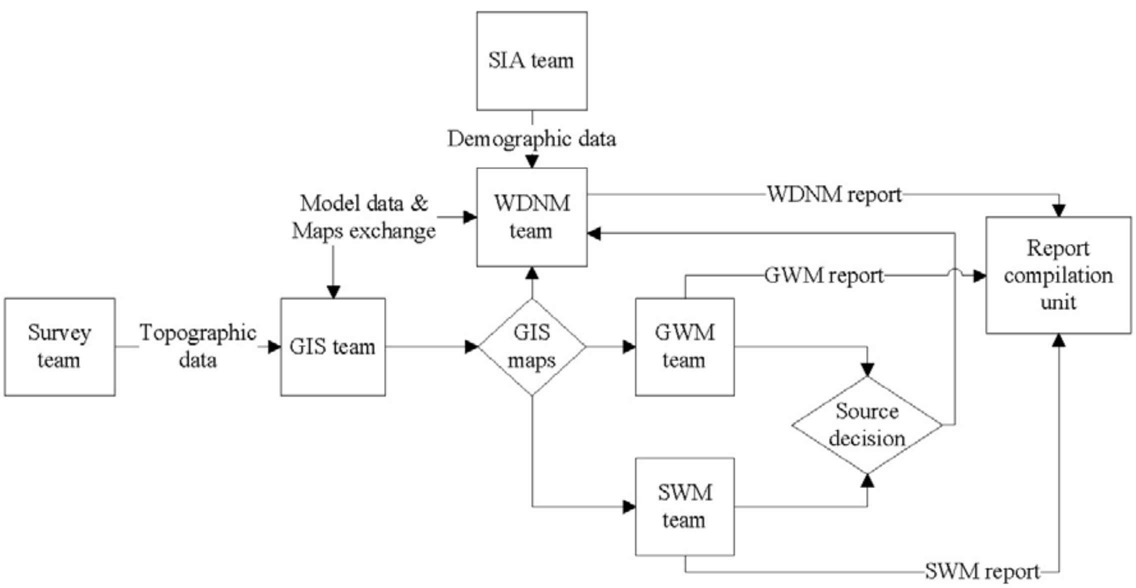


Figure 1. Data flow between the teams for master plan preparation

3.2 *Determination of expected time by PERT*

Program Evaluation and Review Technique (PERT) is used to compute the expected time duration of each activity. Optimistic time (O), pessimistic time (P) and most likely time (M) is derived from the previous time estimates of the activities in former phases of the project. Expected time (T_E) is calculated using the most common equation of PERT analysis giving maximum weights to the most likely time:

$$T_E = \frac{O + 4M + P}{6} \tag{1}$$

The calculation is done in Microsoft Project 2007.

Table 1. Expected time computation by PERT

Activity	Time estimates (days)			
	Optimistic (O)	Most likely (M)	Pessimistic (P)	Expected (T_E)
SIA Survey	7	9	12	9.17
Topographic Survey	15	20	25	20
GIS Mapping	4	5	7	5.17
SW Modelling	15	17	20	17.17
GW Modelling	15	18	20	17.83
Data Input	1.5	2	3	2.08
Population Projection	1.5	2	3	2.08
Demand Assessment	2	3	3.5	2.92
Model Building	0.8	1	1.5	1.05
WDN Modelling	3	5	6	4.83
Reporting	4.5	5	6	5.08

3.3 *Aetermination of critical path by CPM*

After the PERT analysis is done, the network diagram of the activities is developed in Microsoft Project 2007. PERT analysis provides the required expected time (T_E) for each activity. Predecessors of each activity are derived from the data exchange relationship presented in Figure 2.

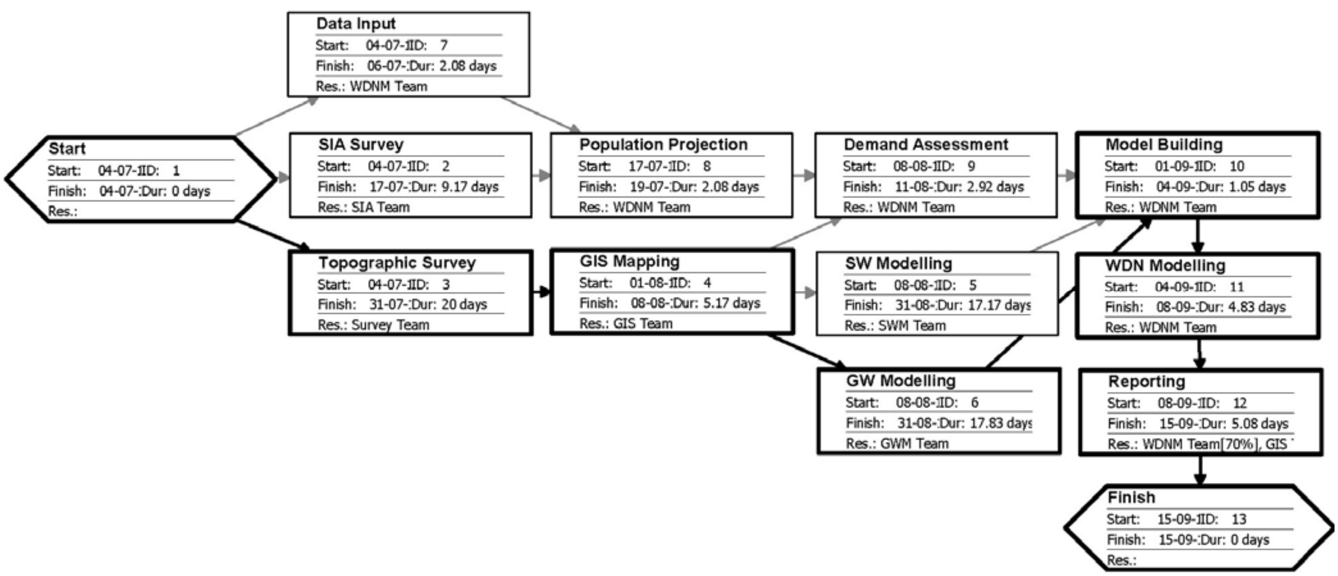


Figure 2. Network diagram and critical path.

The critical path is shown in dark boxes and bold lines in Figure 2. Time span of the critical path is 53.97 working days. Thus, an individual Paurashava's work can be done in about 54 working days. For optimized utilization of the resources, all the teams should be mobilized as such the teams not in critical path can be engaged in the activities of subsequent Paurashavas. Therefore, a full work plan for the whole phase of the project is necessary.

3.4 *Slack/ float determination*

In project management, slack or float is the amount of time that a task in a project network can be delayed without causing a delay to subsequent tasks (*free slack*) and project completion date (*total slack*).
For a specific task, total slack = late start- early start
And free slack = Early start of the successor task – Early finish of the predecessor task – lag between the successor and predecessor task

Slack can be found from Detail Gantt view of Microsoft Project 2007. Details of the slacks are provided in Table 2.

Table 2. Computation of slack/ float

Activities		Start	Finish	Late Start	Late Finish	Free Slack	Early Start	Early Finish	Total Slack
A	SIA Survey	Jul 04	Jul 17	Aug 11	Aug 24	0.83 days	Jul 04	Jul 17	28.83 days
B	Topographic Survey	Jul 04	Jul 31	Jul 04	Jul 31	0 days	Jul 04	Jul 31	0 days
C	GIS Mapping	Aug 01	Aug 08	Aug 01	Aug 08	0 days	Aug 01	Aug 08	0 days
D	SW Modelling	Aug 08	Aug 31	Aug 08	Aug 31	0.67 days	Aug 08	Aug 31	0.67 days
E	GW Modelling	Aug 08	Aug 31	Aug 08	Aug 31	0 days	Aug 08	Aug 31	0 days
F	Data Input	Jul 04	Jul 06	Aug 22	Aug 24	7.92 days	Jul 04	Jul 06	35.92 days
G	Population Projection	Jul 17	Jul 19	Aug 25	Aug 29	13.92 days	Jul 17	Jul 19	28.83 days
H	Demand Assessment	Aug 08	Aug 11	Aug 29	Aug 31	14.92 days	Aug 08	Aug 11	14.92 days
I	Model Building	Sep 01	Sep 04	Sep 01	Sep 04	0 days	Sep 01	Sep 04	0 days
J	WDN Modelling	Sep 04	Sep 08	Sep 04	Sep 08	0 days	Sep 04	Sep 08	0 days
K	Reporting	Sep 08	Sep 15	Sep 08	Sep 15	0 days	Sep 08	Sep 15	0 days

3.5 *Resource utilization*

A report of resource work summary has been prepared in Microsoft Project 2007 and presented in Figure 3. For a single Paurashava, resources of the topographic survey team are most occupied (37.04%) and GIS teams are least occupied (11.74%). On average, 26.86% of the availability of the teams is utilized.

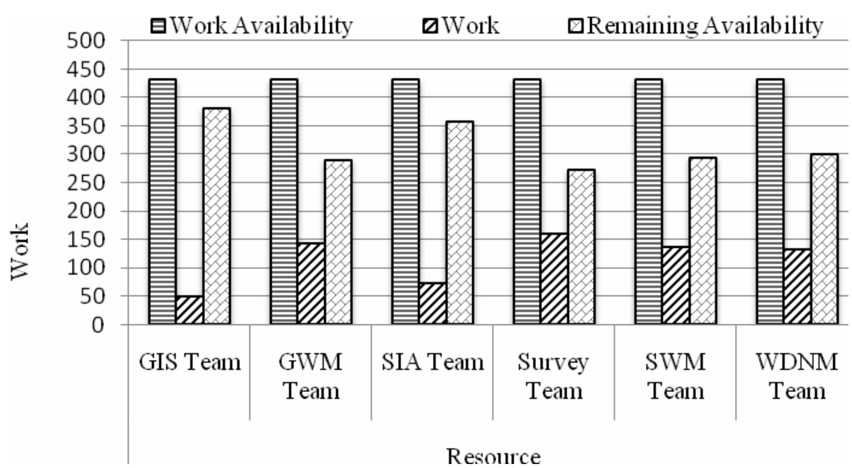


Figure 3. Resource work summary for a single Paurashava..

In order to utilize all the teams' full capacity, a detail time scheduling of the complete project phase is necessary so that a team can proceed to further assignment in its' available slack.

3.6 *Representation of the plan in Gantt chart*

Following the activity planning, time scheduling and resource allocation, planning for water supply master plan preparation of a single Paurashava is complete. Then the plan is represented in a Gantt chart for easy understanding and to set target for the resources (Fig 4). Interconnectivity of different tasks are presented by links; which establishes the predecessor- successor relationships.

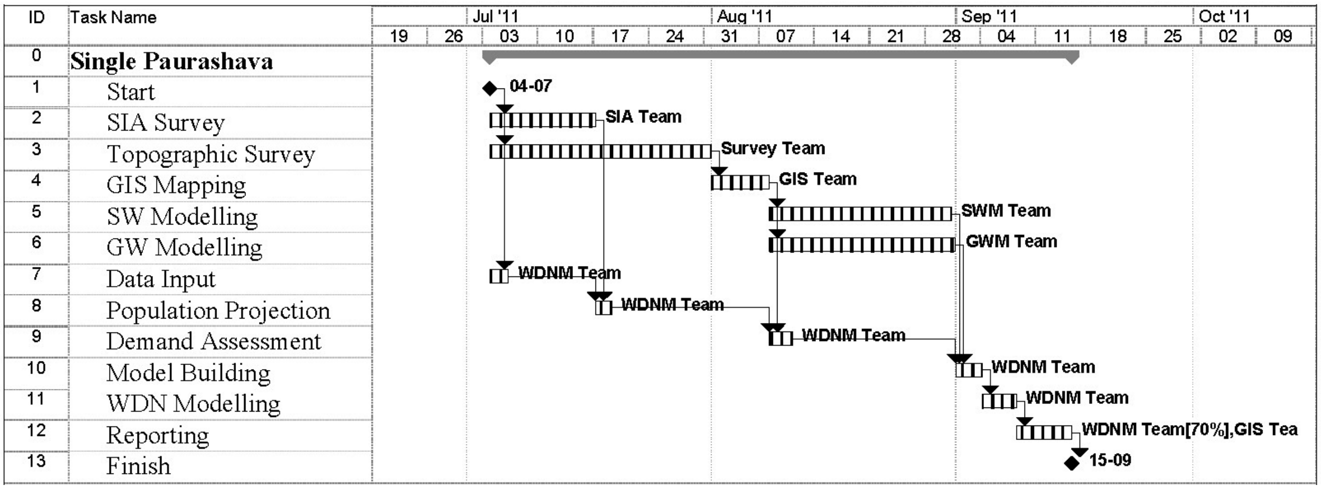


Figure 4. Gantt chart, representing planning for a single Paurashava.

3.7 *Review of progress: Tacking Gantt*

Provision of internal co-ordination and review meeting is kept in the proposed plan. Generally the meeting helds weekly. Hence, weekly progress of each team is reviewed and necessary adjustment can be made. Tacking Gantt chart is prepared for reviewing of total progress made (Fig 5). Weekly progress can also be assessed by including progress line in the Tacking Gantt chart. Figure 5 shows beginning of the project; hence, no progress is seen.

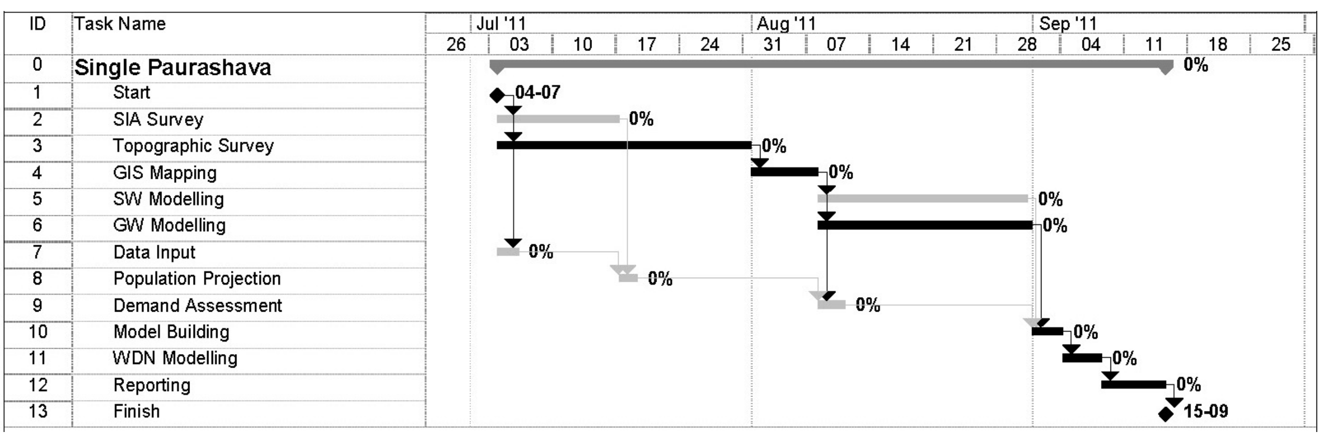
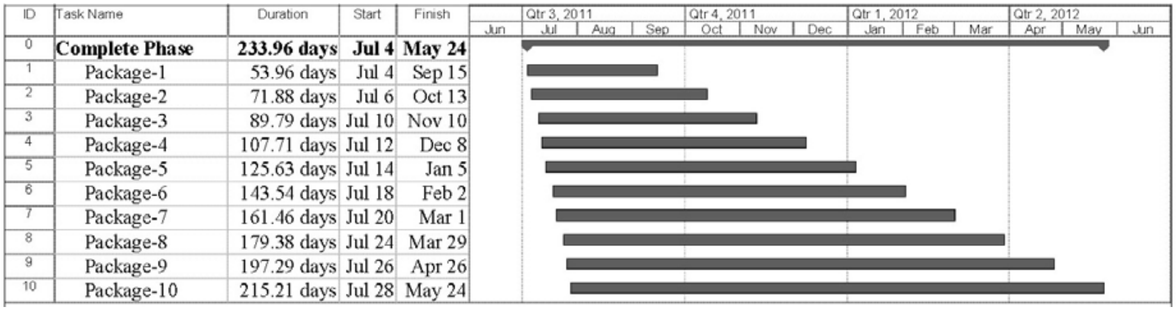


Figure 5. Tacking Gantt chart is used to show work progress

4 COMPLETE PHASE PLAN

Duration of the complete phase is 1 year, starting from July 2011 to finish at June 2012. Total 50 Paurashava's work has to be done in this duration. 5 topographic survey teams are mobilized in the field, which demands 5 Pourashava's work has to be done simultaneously by each modeling team to accommodate with the data flow from survey team. Therefore, the entire work of the project is divided into 10 packages, each package contains 5 Paurashavas. Time scheduling of package-1 is the same as illustrated in section 3. Summary of the complete phase plan is shown in Figure 6.



ID	Task Name	Duration	Start	Finish
0	**Complete Phase**	**233.96 days**	**Jul 4**	**May 24**
1	Package-1	53.96 days	Jul 4	Sep 15
2	Package-2	71.88 days	Jul 6	Oct 13
3	Package-3	89.79 days	Jul 10	Nov 10
4	Package-4	107.71 days	Jul 12	Dec 8
5	Package-5	125.63 days	Jul 14	Jan 5
6	Package-6	143.54 days	Jul 18	Feb 2
7	Package-7	161.46 days	Jul 20	Mar 1
8	Package-8	179.38 days	Jul 24	Mar 29
9	Package-9	197.29 days	Jul 26	Apr 26
10	Package-10	215.21 days	Jul 28	May 24

Figure 6. Summary of complete phase plan

Each team continues to work on successive package's task after finishing respective task of previous package. Thus, capacity utilization of the teams is increased and resource utilization is optimized. Obviously, full capacity of a team cannot be utilized due to dependency on other teams for data support. Therefore, some slack still remains in the noncritical tasks.

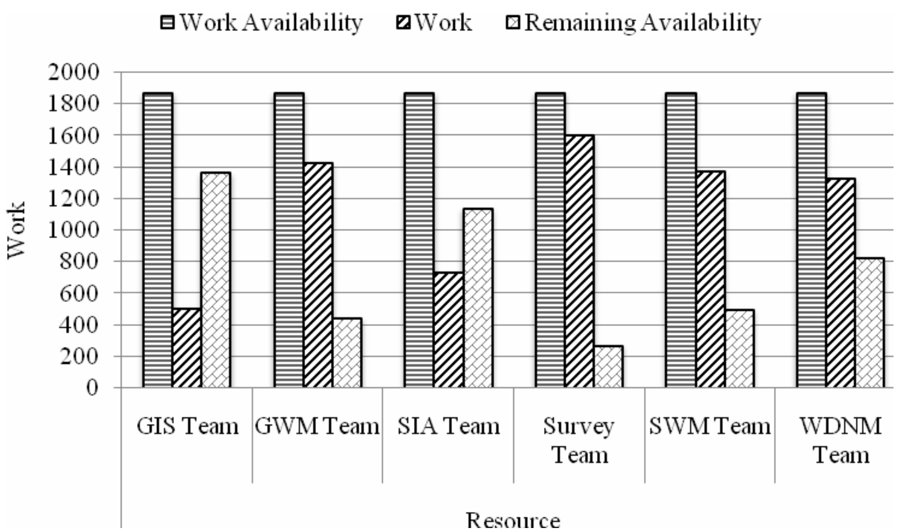


Figure 7. Resource work summary report for full phase

Comparing Figure 5 and Figure 7, it can be inferred that resource utilization increased in the complete phase plan than a single Paurashava plan. On average 62.06% of the teams' capacity are utilized in the complete plan. For avoiding complexity in the time scheduling, only weekly holidays are considered. In actual case, other holidays and unavoidable circumstances dismount working time and hence resource availability. Besides, training of the fresh recruits also consumes working hours and output from them takes more time than a regular resource. Considering these issues, the slacks in the time schedule are desirable.

5 CONCLUSIONS

This paper presents the activities planning and time scheduling as well as resource allocation of a water supply master plan preparation project. For performing this assignment, the well known PERT analysis is used in conjunction with the CPM technique. Gantt chart is used also for easy interpretation of results to the planners. For progress review, Tacking Gantt Chart is adopted. While planning, probability of conflict regarding data transfer is eliminated providing sufficient but optimized slack to the resources.

The planning is done for the current phase of the project and hence, experiences from the previous phases are exploited in task duration assessment and particular resource's capacity assigning for resource allocation. This planning methodology can be exploited successfully in similar type of projects.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contribution of all team members of this project. Particularly, Mr. Monowar Ali, Project Direcor, Ground Water Management Project, DPHE is appreciated for his kind consent to the authors for this publication. the invaluable support of Mr. Emaduddin Ahmad, Team Leader, Comp-I, Mathematical Modelling for safe Drinking Water Source Identification, DPHE and Mr. S M Mahbubur Rahman, Director, Water Resources Planning Division, IWM. The authors are also thankful to colleagues of IWM- Mr. Mustafa Tanveer Hasan, Ms. Tanjia Akter Amy, Mr. Md. Abdullah and Mr. Md. Kamrul Hossain for their contribution in this particular assignment.

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