# Integer programming for selecting the best playing XI of an IPL team

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## ABSTRACT

*Since the inauguration of Twenty20 cricket in 2007 with the first Twenty20 world cup, there has been a huge amount of excitement among the supports about this shorter format of the game. It has also increased television viewership to a large extent. The Indian Premier League (IPL) which started in the year 2008, brought about a larger number of fans following and helped the board, franchise owners and the players generate profitable returns. This paper helps us analyze and formulate the optimal starting XI for a cricket team. The team that we have selected is Kolkata Knight Riders which is a franchise playing in the IPL. To formulate the problem, the integer programming model is being used in the paper which helps us in obtaining the best possible playing XI. Performance measures such as the batting and bowling ability help us in formulating the problem. An illustration of the method is provided, and the data is taken based on the statistics of the players of Kolkata Knight Riders from the previous season, i.e., the 2020 IPL season.*

*Keywords— Cricket, Integer Programming Model, Optimal Starting XI, Indian Premier League, Batting Ability, Bowling Ability*

## 1. INTRODUCTION

Popular Indian Premier League team and two-time winners Kolkata Knight Riders (KKR) has been in a slump lately. They have not won a single title since 2014 and have even failed to qualify for the play-offs stage for the past two seasons. (Kolkata Knight Riders, n.d.)

The Operations Research (OR) technique that we have used in this paper is being applied to the sport cricket. Cricket is a game played between two teams consisting of 11 players each. There are various formats under cricket which are Test Cricket, One-Day International and the Twenty-20 format. The test cricket format is a 5-day game in which each team plays two innings i.e., the team's bat and bowl twice. There are two breaks during a day and 90 overs are needed to be completed in a single day. There have been variations in this format over the last few years with the 4-day test format and the day and night matches coming into play. The next format which is the one-day internationals is a 50 over game played between two teams. The last format which is Twenty-20 cricket is a 20 over format which was introduced in 2007 for the first time with the thought that it would attract more spectators and television viewership since this is the fast-paced format which gets over in about 4 hours. (History of Cricket, n.d.) (THE EVOLUTION OF CRICKET – A HISTORY, 2018)

Operations research is being used in cricket for a long time. Each part of the game now needs vigorous planning both on-field and off-field. It is used in planning the matches of different teams at different locations and selecting the players during the auctions. It is also used in cricket fantasy leagues. One of the most prominent contribution is the Duckworth Lewis Method. This method is used when the match has been shortened due to various reasons and it helps in calculating how many runs and overs will be reduced according to the time restrictions. There are various tournaments that are played around the world, and in our research, we are focusing on the Indian Premier League (IPL) which is a franchise-based competition played between eight teams. The format used is of Twenty-20 cricket. It is a league in which each team plays a total of 14 matches facing all the other 7 teams twice in a home and away format. (Chaudhari, 2014)

Integer programming is basically a program used for mathematical optimization in which some or all variables are restricted to be integers. It is also commonly known as integer linear programming (ILP) because all the constraints are linear. Integer Programming is the class of problems that can be expressed as the optimization of a linear function subject to a set of linear constraints over integers. (What is integer programming?, n.d.) (Massachusetts Institute of Technology)

Integer Programming can be used to solve many problems including the ones in cricket. As we have seen the use of OR in cricket has been rapidly increasing and with such rapid advancements' teams need to explore various options as to how they can make their teams better. In several cricket formats like ODI, Twenty20 and Test matches, several teams make use of integer programming. It is essential for every team to choose their optimal players for a match against any team, be it any format. With the help of this technique, cricket teams can select the best players for their team. Integer Programming can be used to find the most suitable starting 11, a team with the best 15 players or more. Each cricket team can adjust the constraints with respect to what kind of players they want. For example, if a team wants more bowlers than batsmen or vice-vera, they can adjust the constraints accordingly. This way a team can decide whether they want a batting-oriented team or a bowling-oriented team.

The research was carried out to find the optimal starting XI using integer programming for the Indian Premier League franchise Kolkata Knight Riders. Various types of statistics in regard to the player's past performance in the Indian Premier League have been used. These statistics include batting average, strike rate, bowling average etc. according to the respective players strengths. Several constraints such as 4 batsmen, 1 wicketkeeper, 4 bowlers, and 2 all-rounders were chosen and in accordance with these constraints, we aimed to find the perfect starting XI for the franchise.

## 2. RESEARCH OBJECTIVE
The main objective of this paper is to find an optimum solution to get a perfect team of eleven players for a cricket match in the Indian Premier League, using the Integer Programming. In the past, various methods have been applied such as ranking method, fixed budget performance analysis, pareto-optimal front etc; however, these methods have a set of drawbacks and limitations, which result in the formation of an unbalanced team i.e., the team is not optimised.

The team selection for the Indian Premier League is a major and an important decision to make. There are already several limitations and constraints when it comes to a budget and also a new talent face coming in each year. The above stated methods simply complicate the selection process further. Therefore, to overcome these limitations, and to form a balanced and optimised team of 11 players, Integer Programming Method is suggested to be utilised.

## 3. LITERATURE REVIEW
A multi-objective optimisation and multi-standard decision-making problem occurs while choosing a cricketer on a fixed budget. In the sport of Cricket, a team's performance is affected and determined by the hitting power and bowling power of the team members. Therefore, optimisation is necessary in order to build a strong and successful team. (Ahmed, Deb, & Jindal, 2013)

The Indian Premier League was started in 2008 by the Board of Control for Cricket in India, and it is a cricket league that follows the popular Twenty20 or T20 format. The Indian Premier League is based on a mixture of league and knockout format. There are a total of 8 teams where each team plays a total of 14 matches, i.e., 2 matches against each team, both home and away. Each team consists of a maximum of 25 players, which includes 8 overseas players. During a match each team is allowed to have a total of 11 players, which can include a maximum of 4 overseas players in a match. The top scoring 4 teams qualify for the play-off rounds from which ultimately helps to declare the winner of the Indian Premier League. (Vasudevan, Varma, J, M, & Nair, 2020)

Analytics and various types of mathematically extensive techniques have been used in Cricket, to help figure out various things, though the use of the same is done in a very contained manner. Different ranking methods, such as indices, are used to calculate the number of fours and sixes scored by a batsman in the innings, the batting average and the strike rate (average no. of runs scored per 100 balls played by one batsman). Furthermore, there is a unique technique to calculate the bowling averages and bowling strike rates for each player, which also helps in evaluating bowlers' performances. Alternatively, there are metrics to assess performances of players using Duckworth/ Lewis percent values as well. (Singla & Shukla, 2020)

This paper will speak about the ways through which OR/MS can be used in the sport of Cricket. Some of the reasons stated for writing down the paper was that the game is globally popular, and its popularity seems to be growing every day; but also, the fact that there have to be various strategic decisions made during a Cricket match. Moreover, as time has passed, the sport of Cricket has now become much more analytical. The paper will also showcase that the OR/MS has been used to make strategic decisions such as team selection, batting order, the decision of batting or fielding which a team must first opt for, and also when to declare. OR is being used when the match has been stopped due to unfavourable conditions such as bad weather conditions, bad lighting etc. The Duckworth Lewis method is said to be one of the most prominent methods which is used to declare a winner in cases of the above circumstances. (Wickramasinghe, 2014)

The paper talks about different measures of performance analysis with a fixed budget kept in mind. They compared their analysis with a popular Indian Premier League team known as Chennai Super Kings, using a Pareto-optimal front. The effect of a budget constraint is analysed with the help of a budget sensitivity analysis. The study shows how the budget constraint affects a batting-oriented team rather than a bowling-oriented team. This is because the price difference between a batsman with a higher batting average than a batsman with lower batting average is significantly different. (Ahmed, Deb, & Jindal, 2013)

This study also shows how integer programming has been used for the selection of a team. The decision variables are defined to determine whether or not an individual is good enough to be selected on the basis of the optimisation of a linear function for pre-defined criteria. (Sharp, Bretteny, Gonsalves, Lourens, & Stretch)

To mainly summarise this programme in short, this program helps in the optimisation of a linear function subject to a set of linear constraints over an integer variable. There are 2 types of integer programmes, first, when there are some but not all variables that are integers, it is called a mixed integer program; second, when all decision variables must be integers, it is called a pure integer programme. (Kavun, Dhaifullah, & Daradkeh, 2015)

The Scheduling Integer Programming model is referred to as sequencing, scheduling and routing. In this study, this model is used for selection of teams in the Indian Premier League franchise. The perfect selection of 11 players to play a match in the sport of Cricket, with a good balance between the players' performances, and to maximise optimisation is a difficult task. Hence, to make this process easier, the Scheduling Integer Programme is used. This programme gives various useful methods to select good players from a set of players provided for selection, in order to make a solid team of 11 players. (Sharp, Bretteny, Gonsalves, Lourens, & Stretch)

Some areas that are taken into consideration are- batting average of a player, which is the total number of runs scored by the player divided by the number of times he has been out. The concept of ideology behind the same is that the ratio between number of runs scored by a player and the number of times he has been declared out, determines the player's ability to drive the game alone. Another ideology is that the batting average extracted may be a trustable metric to determine a player's batting skill as a suitable batsman for the team, and similarly in the case of a bowler, the lower the batting average, better is the bowler's track record. (Bhattacharjee & Saikia, 2016) (Sharp, Bretteny, Gonsalves, Lourens, & Stretch)

# 4. METHODOLOGY
## 4.1 Background
In cricket, the goal is to score as many runs as possible while allowing the opposition team to score as few runs as possible. To score runs, the team must have players who can bat well; batting average and batting strike rate are two prominent measurements of batting performance. Limiting the opposition's score necessitates the presence of players who can bowl well. Bowling economy rate, bowling average, and bowling strike rate are three popular measurements of bowling performance that can be used to limit the opposition's score.

## 4.2 Integer Programming
For team selection, integer optimization needs the optimization of a linear objective function with linear constraints and integer constraints on the decision variables. The integer constraints are binary, with a zero indicating non-selection and a one indicating selection. The programming model's linear constraints are utilized to ensure that a suitable number of players are chosen for each ability. A minimum number of batters, a minimum number of bowlers, a minimum number of all-rounders, ensuring the selection of a wicketkeeper, and even ensuring the selection of a captain if considered necessary are all examples of team selection constraints. Constraints are only included if they make cricketing sense; a simple example would be including the requirement that a team contains exactly 11 players. Two constraints are used to define this restriction. The constraint $\sum_{i=1}^{m} \sum_{j=1}^{ni} x_{ij} = 11$ must be included to ensure that 11 players are chosen. This constraint guarantees that all 11 decision variables are equal to one. We use $\sum_{i=1}^{m} x_{ij} \leq 1$ for all j to make sure no player is selected more than once. These two requirements work together to ensure that a team of exactly 11 players are chosen. (Sharp, Brettenny, Gonsalves, & Lourens, 2011)

## 4.3 Batting Statistics
This research looks at two types of batting statistics that are often used to measure player performance, namely the average number of battings of a player, called $Y_{1j}$, and the player's batting rate, called $Y_{2j}$. The statistic is defined as follows:

$$\text{Batting Average } Y_{1j} = \frac{\text{Total number of runs scored by player j}}{\text{Total number of dismissals for player j}}$$

$$\text{Batting Strike Rate } Y_{2j} = \frac{\text{(Total number of runs scored by player j}}{\text{Total number of balls received by player j}} \times 100$$

If a batsman has high values for $Y_{1j}$ and $Y_{2j}$, he is considered to be a good player. Using these values, the batting ability was calculated which is defined as $U_{1j} = (Y_{1j}^{a})(Y_{2j}^{1-a})$ where $0 \leq a \leq 1$. The batting index is also calculated which is $C_{1j} = \frac{U_{1j}}{\sum_{j=1}^{n1} U_{1j}} \times n1$ where $U_{2j}$ is the batting ability for player j and n1 is the number of batsmen for whom batting abilities are available.

## 4.4 Bowling Statistics
This research looks at three bowling statistics that are commonly used to measure player performance: the economic rate of bowlers ($Y_{3j}$), the average bowling rate of bowlers ($Y_{4j}$), and the hit rate of bowlers ($Y_{5j}$). The statistic is defined as follows:

$$\text{Bowling Economy Rate } Y_{3j} = \frac{\text{Total number of runs conceded by bowler j}}{\text{Total number of overs bowled by bowler j}}$$

$$\text{Bowling Average } Y_{4j} = \frac{\text{Total number of runs conceded by bowler j}}{\text{Total number of wickets taken by bowler j}}$$

$$\text{Bowling Strike Rate } Y_{5j} = \frac{\text{Total number of balls bowled by bowler j}}{\text{Total number of wickets taken by bowler j}}$$

A bowler with low values for $Y_{3j}$, $Y_{4j}$ and $Y_{5j}$ is said to be a good bowler. Using these values, we get bowing ability $U_{2j} = (Y_{3j}^{a1})(Y_{4j}^{a2})(Y_{5j}^{1-a1-a2})$ where $0 \leq a1 \leq 1$, $0 \leq a2 \leq 1$, $0 \leq a1+a2 \leq 1$. Bowling performance is measure as $V_{2j} = k - (\frac{U_{2j}}{\sum_{j=1}^{n2} U_{2j}})$ where k is a constant chosen as the smallest positive value such that $k - (\frac{U_{2j}}{\sum_{j=1}^{n2} U_{2j}}) > 0$. The bowling ability indices $(c_{2j}^1) = (\frac{V_{2j}}{\sum_{j=1}^{n2} V_{2j}}) \times n_2$ ensures that the coefficient distributed is the same as the batting coefficient. The higher the bowling index, the better the bowler. The index scales are adjusted so that the bowling and batting indices are equal. This function is defined as $c_{2j}^{p+1} = c_{2j}^{p} {}^{(\sigma_{c1}/\sigma_{c2}^p)}$, where $\sigma_{c1}$ is the standard deviation of the batting index and $\sigma_{c2}^p$ is the standard deviation of the bowling index for the $p^{th}$ iteration.

## 4.5 All-Rounder Statistics
In the sport of cricket, some players are good at batting as well as bowling, these players are known as all-rounders. The all-rounder index is $c_{3j}^1 = (c_{1j})^\beta (c_{2j})^{1-\beta}$, where $0 \leq \beta \leq 1$.

## 5. ANALYSIS AND FINDINGS
This research was conducted to find an optimal team for Kolkata Knight Riders competing in the Indian Premier League (IPL) against 7 different teams. We have taken in account different statistics and calculated various indices which helped in formulating the integer optimization problem, which was further solved using an Excel feature named Solver. Using integer programming, we were able to obtain the best XI for Kolkata Knight Riders based on the performance of the players in the year 2020 according to their specialized fields (batting, bowling, all-rounder, wicket-keeper).

**Table 1: Batting Statistics and Indices of the 10 best-ranked batsmen**

| Sr no. | Player Name | Innings | Runs | Avg | SR | Batting ability | $C_{1j}$ |
|---|---|---|---|---|---|---|---|
| 1 | Shubman Gill | 14 | 440 | 33.84 | 117.960 | 77.798 | 1.361 |
| 2 | Eoin Morgan | 14 | 418 | 41.8 | 138.410 | 92.862 | 1.625 |
| 3 | Nitish Rana | 14 | 352 | 25.14 | 138.580 | 78.449 | 1.373 |
| 4 | Rahul Tripathi | 11 | 230 | 23 | 127.070 | 71.879 | 1.258 |
| 5 | Dinesh Karthik | 14 | 169 | 14.08 | 126.110 | 60.725 | 1.063 |
| 6 | Pat Cummins | 11 | 146 | 20.85 | 128.070 | 69.931 | 1.224 |
| 7 | Sunil Narine | 9 | 121 | 13.44 | 142.350 | 64.819 | 1.134 |
| 8 | Andre Russell | 9 | 117 | 13 | 144.440 | 64.730 | 1.133 |
| 9 | Lockie Ferguson | 2 | 43 | 0 | 148.270 | 0.000 | 0.000 |
| 10 | Kamlesh Nagarkoti | 6 | 22 | 7.33 | 70.960 | 33.295 | 0.583 |
| 11 | Tom Banton | 2 | 18 | 9 | 90.000 | 41.774 | 0.731 |
| 12 | Shivam Mavi | 3 | 10 | 5 | 71.420 | 29.435 | 0.515 |

*(Source: The Authors)*

**Table 2: Bowling Statistics and Indices of the 10 best-ranked bowlers**

| Sr no. | Name | Match | In | Overs | Runs | Wkts | Avg | Eco | SR | Bowling ability | Bowling performance | Bowling Ability indices | $C_{2j}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Varun Chakaravarty | 13 | 13 | 52 | 356 | 17 | 20.94 | 6.84 | 18.35 | 15.317 | 0.142 | 1.434 | 1.603 |
| 2 | Pat Cummins | 14 | 14 | 52 | 409 | 12 | 34.08 | 7.86 | 26 | 22.072 | 0.112 | 1.130 | 1.173 |
| 3 | Shivam Mavi | 8 | 8 | 26 | 212 | 9 | 23.55 | 8.15 | 17.33 | 16.730 | 0.135 | 1.370 | 1.511 |
| 4 | Lockie Ferguson | 5 | 5 | 19.5 | 148 | 6 | 24.66 | 7.46 | 19.83 | 17.319 | 0.133 | 1.344 | 1.473 |
| 5 | Andre Russell | 10 | 7 | 18 | 175 | 6 | 29.16 | 9.72 | 18 | 19.639 | 0.123 | 1.239 | 1.324 |
| 6 | Sunil Narine | 10 | 10 | 38 | 302 | 5 | 60.4 | 7.94 | 45.6 | 33.901 | 0.059 | 0.597 | 0.509 |
| 7 | Kamlesh Nagarkoti | 10 | 9 | 26 | 231 | 5 | 46.2 | 8.88 | 31.2 | 27.731 | 0.087 | 0.875 | 0.839 |
| 8 | Prasidh Krishna | 6 | 6 | 17.3 | 164 | 4 | 41 | 9.37 | 26.25 | 25.358 | 0.097 | 0.982 | 0.976 |
| 9 | Kuldeep Yadav | 5 | 4 | 12 | 92 | 1 | 92 | 7.66 | 72 | 46.482 | 0.003 | 0.030 | 0.010 |

*(Source: The Authors)*

**Table 3: Statistics and Indices of the 10 best-ranked all-rounders**

| Sr no. | Player Name | Innings | Runs | Overs | $C_{1j}$ | $C_{2j}$ | $C_{3j}$ | $C_{3j}^{(p+1)}$ |
|--------|-------------|---------|------|-------|----------|----------|----------|------------------|
| 1 | Shivam Mavi | 8 | 10 | 26 | 0.52 | 1.37 | 0.84 | 0.84 |
| 2 | Andre Russell | 10 | 117 | 18 | 1.13 | 1.24 | 1.18 | 1.18 |
| 3 | Sunil Narine | 10 | 121 | 38 | 1.13 | 0.60 | 0.82 | 0.83 |

*(Source: The Authors)*

## 5.1 Integer Programming Model

To achieve the desired goal, the integer programming model is defined for the following decision variables:

$$\text{Let } x = \begin{cases} 1, \text{ if player j is selected for i} \\ 0, \text{ otherwise} \end{cases}$$

Where,

$$\text{Discipline i} = \begin{cases} 1, \text{ if batting ability} \\ 2, \text{ if bowling ability} \\ 3, \text{ if all-rounder ability} \\ 4, \text{ if wicketkeeping ability} \end{cases}$$

**Objective Function:**

$$\text{Maximize } Z = \sum_{i=1}^{4} \sum_{j=1}^{ni} c_{ij} x_{ij}$$

Subject to constraints:

$$\sum_{i=1}^{4} \sum_{j=1}^{ni} x_{ij} = 11$$

$$\sum_{j=1}^{4} x_{4j} = 1$$

$$\sum_{j=1}^{n3} x_{3j} \geq 0$$

$$\sum_{j} (x_{1j} + x_{3j}) \geq 6$$

$$\sum_{i=1}^{4} x_{ij} \leq 1$$
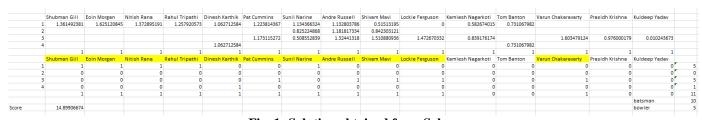
$$\sum_{j} (x_{2j} + x_{3j}) \geq 5$$



**Fig. 1: Solution obtained from Solver**
*(Source: The Authors)*

As displayed below in Table 4, the optimal playing XI would comprise of Shubman Gill, Eoin Morgan, Nitish Rana, and Rahul Tripathi as the batsmen, Dinesh Karthik as the wicketkeeper-batsman, Sunil Narine, Andre Russell, and Shivam Mavi as the all-rounders, and Pat Cummins, Lockie Ferguson, and Varun Chakaravarty as the bowlers. The result gave us a perfect balance of the starting 11 as there are five batsmen, three bowlers, and three all-rounders which plays to Kolkata Knight Riders' strengths as they have a stronger batting side.

**Table 4: Optimal Playing XI**

| Player Name | Specialisation |
|-------------|----------------|
| Shubman Gill | Batsman |
| Eoin Morgan | Batsman |
| Nitish Rana | Batsman |
| Rahul Tripathi | Batsman |
| Dinesh Karthik | Wicketkeeper – Batsman |

| Pat Cummins | All-Rounder |
|---|---|
| Sunil Narine | All-Rounder |
| Andre Russell | All-Rounder |
| Shivam Mavi | Bowler |
| Lockie Ferguson | Bowler |
| Varun Chakaravarty | Bowler |

*(Source: The Authors)*

Since the number of overs are too scarce in an IPL match, our approach places a huge importance on the batting strike rate and the bowling economy as a higher batting strike rate portrays the batsman's aggressive batting ability while a lower bowling economy justifies a good bowling performance by giving away as less runs as possible. These constraints can be altered as per the format of the match and integer programming can subsequently be used to select the playing XI for other formats including One-Day Internationals and Test matches.

## 6. CONCLUSION

Our study successfully met its objective and the best playing XI was obtained using Integer Optimization Programming, with a few drawbacks which are mentioned later. With a wide range of application, the technique places heavy importance on the past records of players and this makes it quite effective. This study can further help Kolkata Knight Riders in ending their title drought and aid them in winning the Indian Premier League after a dry spell of 7 years.

This study's contributions include the defining of an integer programming model for selection of an 11-person cricket team. The model adds to the research of Gerber and Sharp (2006) by extending the modelling framework to Twenty20 cricket. In addition, the coefficients in the model is determined by defining ability indices that are both scale and location adjusted. Ability measures for Twenty20 cricket are defined by incorporating the methods of Lemmer (2004), Barr et al (2008) and Lourens (2009). The methodology is discussed in Section 2. In particular, the cricket statistics are defined and coefficient indices justified.

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## 7. LIMITATIONS AND RECOMMENDATIONS

Our study is successful in helping the team management obtain the best playing XI based on the past records of the players. But it fails to surpass a huge challenge posed by the rules laid down by BCCI which allows an IPL team to play only four non-Indian players in a match.

Furthermore, our study does not consider the nature and the type of the pitch, and the size of the ground. These factors can affect the type of bowler – spinner or pacer – a team would want to select. For instance, a team would want to select more spinners than pacers if the pitch is dry and dusty which facilitates the turning ability due to cracks present all over the surface. Additionally, since our study places a huge importance on the player's performance in the past season of IPL, a player making his debut in the new season in unlikely to be selected using our method as he does not have any past records.

Lastly, while selecting a wicketkeeper in the playing XI, our study does not take in account the statistics which are the most important factors to judge a wicketkeeper, i.e., the number of catches taken by him behind the wicket and the number of stumpings performed by him. While we failed to cover these gaps in our study, these limitations provide a gateway to future young minds for not only overcoming these shortcomings but also extend the research area to new horizons.

## 8. REFERENCES

[1] Ahmed, F., Deb, K., & Jindal, A. (2013). Evolutionary Multi-Objective Optimization and Decision-Making Approaches to Cricket Team Selection. Kanpur: Elsevier B.V.
[2] Bhattacharjee, D., & Saikia, H. (2016). An objective approach of balanced cricket team selection using binary integer programming method. Retrieved from Infona: https://www.infona.pl/resource/bwmeta1.element.springer-doi-10_1007-S12597-015-0228-3/tab/summary.
[3] Kavun, S., Dhaifullah, M., & Daradkeh, D. (2015). Method of the Integer Linear Programming. Mitteilungen Klosterneuburg.
[4] Singla, S., & Shukla, S. S. (2020). Integer Optimisation for Dream 11 Cricket Team Selection. IJCSE International Journal of Computer Sciences and Engineering.
[5] Vasudevan, R. P., Varma, A. J., J, A., M, R. K., & Nair. (2020). Indian Premier League -cricket, entertainment or business, Journal of the Social Sciences.
[6] Wickramasinghe, I. P. (2014). Predicting the performance of batsmen in test. Journal of Human Sport & Exercise.
[7] Chaudhari, A. (2014). Study and Analysis of Duckworth Lewis Method. Research Gate.
[8] History of Cricket. (n.d.). Retrieved from ICC: https://www.icc-cricket.com/about/cricket/history-of-cricket/early-cricket

[9]   Kolkata Knight Riders. (n.d.). Retrieved from Sportskeeda: https://www.sportskeeda.com/team/kolkata-knight-riders

[10] Massachusetts Institute of Technology. (n.d.). Integer Programming.

[11] The evolution of cricket – A History. (2018, July 4). Retrieved from Keith Prowse: https://www.keithprowse.co.uk/news-and-blog/2018/07/04/the-evolution-of-cricket-a-history/

[12] What is integer programming? (n.d.). Retrieved from IBM.

[13] Sharp, G., Brettenny, W., Gonsalves, J., & Lourens, M. E. (2011). Integer optimisation for the selection of a Twenty20 cricket team. Journal of the Operational Research Society.