APPENDICES

[I] COBB - DOUGLAS PRODUCTION FUNCTION

[II] TECHNOLOGY ADOPTION INDEX.

[III] QUESTIONNAIRE

[IV] LIST OF VILLAGES SELECTED FOR SAMPLING
APPENDIX - I

COBB - DOUGLAS PRODUCTION FUNCTION

**PRODUCTION FUNCTION** -

"Production function is the relationship between the maximum amount of output that can be produced and the inputs required to make that output for the given state of technical knowledge". (Paul. A. Samuelson)

Production function generally obeys the law of diminishing returns, because, as more of an input such as labour is added to a fixed amount of land, machinery and other inputs, the labour has less and less of the other factors to work with. The Land gets more crowded, the machinery is over worked, and the job done become less important.

In applying the law of diminishing returns of production we must emphasize that, it is widely, observed empirical regularity rather than a universal truth like the law of gravity.

Therefore, the law of diminishing returns is an empirical regularity, subject to exceptions and not a universal law of nature. (Samuelson)

Probably the simplest and the most widely used production function in economics is the Cobb-Douglas production function. The main reasons for its popularity are certain interesting properties which this form of production function possess as well as the computational ease in its empirical estimation.
C.W. Cobb and P.H. Douglas (1928) used this function for estimating the relationship between inputs and output only in manufacturing industries in U.S.A. But now-a-days this form of production function is applied to whole economic system.

The Cobb-Douglas production function is $Q = AK^a \cdot L^{1-a}$ Where Q is the output, K is the capital employed, L is the amount of labour employed and A and a are positive constants where 'a' is less than 1.

Cobb-Douglas production function states that about 75% of the increase in the manufacturing output is due to the labour input and the remaining 25% only is due to the capital input. To put it in other words, the Cobb-Douglas production function $Q=AK^\frac{a}{2} \cdot L^{\frac{1}{2}}$ Which shows constant returns to scale because the total value K and L is equal to one $(\frac{a}{2} + \frac{1}{2})$. The generalised version of this function is -

$$Q = AK^a \cdot L^b$$ (Where 'a' is greater than 0 and 'b' is greater than 0)

The function is linear and homogeneous of degree one. To prove it, let us increase of K and L by 2 times. The output Q will be -

$$Q = A(2K)^a \cdot (2L)^b = 2^a \cdot 2^b \cdot (AK^a \cdot L^b) = 2Q$$ (Therefore $a+b = 1$)

Thus, the output Q becomes 2Q when the inputs are increased two folds.
FEATURES OF COBB-Douglas Production Function -

The Cobb-Douglas Production function has some unique features which are highly useful in empirical studies.

1) **It is Simple to handle**

The multiplicative form of the function $AK^a \cdot L^b$ can be transformed in to a LOG-LINEAR FORM -

$$\log Q = \log A + a \log K + b \log L$$

In this form it is simple to handle.

2) **Constant Returns to Scale**

Often the function is used in the form

$$Q = AK^a \cdot L^{1-a}$$

The function implies constant returns to scale where $a+b=1$. It is not necessary that $a+b=1$. The function implies constant returns to scale if the sum of the exponents equals 1. If their sum is greater than 1, increasing returns to scale prevail. Decreasing returns to scale prevail if their sum is less than 1.

3) **Declining Marginal Products**

The Cobb-Douglas production function implies declining Marginal products for all inputs. Consider input K -

$$A = AK^a \cdot L^b$$

$$\frac{dQ}{dK} = aAK^{a-1} L^b$$

$$\frac{d^2Q}{dK^2} = a(a-1)AK^{a-2} L^b > 0$$
Since 'a' is a positive fraction, (a-1) is negative. Thus, the rate on change of the marginal product of input K is negative, and MPK declines.

4) **Output Elasticity** -

'a' and 'b' show the output elasticity coefficient for inputs K and L. The output elasticity 'E' is defined as the ratio of the relative change in output over a relative change in input.

The output elasticity coefficient in respect of capital may be defined as a proportional change in output as a result of a given change in K (L remaining constant). Thus:

\[
E_k = \frac{dQ}{dK} \cdot \frac{K}{Q} = \frac{dQ}{dK} \cdot \frac{K}{Q}
\]

By differentiating the production function,

\[Q = AK^a L^b\]

with respect to K we get

\[
\frac{dQ}{dK} = aAK^{a-1} L^b
\]

By substituting the values \(\frac{dQ}{dK}\) and Q into the output elasticity formula -

\[
E_k = \frac{\frac{dQ}{dK} \cdot K}{Q} = \frac{aAK^{a-1} L^b K}{AK^a L^b} = a
\]

Thus output elasticity coefficient for k is 'a'. Clearly, the same procedure holds for factor L.
5) Relative Distributive shares -

'a' and 'b' show the relative distributive shares on inputs K and L. The relative distributive share of input K is given by:

\[ \frac{\frac{dQ}{dK} \cdot K}{Q} = aAK^{a-1}L^b, K = aAK^aL^b \]

Where K is the quantity of input K. The relative share of K can be obtained as follows:

\[ \frac{dQ}{dK} \cdot \frac{K}{Q} = aAK^{a-1}L^b, K = aAK^aL^b \]

Likewise 'b' represents the relative share to L in Q.

**APPLICATION OF COBB-DOUGLAS FUNCTION IN INDIAN AGRICULTURE**

Various attempts have been made so far to apply Cobb-Douglas function in Indian agriculture. Hanumantha Rao attempted to use it in old Hyderabad State Telangana, Marathwada and Karnataka regions. Rajkrishna used it, on Punjab State and recently Mohd. Shafi applied it on Uttar Pradesh. Besides, Saran V. Chenna Reddy, Bardhan and J.P. Singh have also attempted to use it in various states. Hanumantha Rao's study (1953-54) was based on the data regarding gross output, inputs of land, labour and capital pertaining to 345 farms of the old Hyderabad State, comprising Telangana, Marathwada and Karnataka regions. The study comprises three stages -

(i) It starts with simple output - input relationship by means of the ratio of output to individual inputs, such as output per unit of land, labour and capital. In this stage, factor ratios such as land labour, land-capital and capital labour are also examined.
(ii) In the second stage study examines the elasticities of output with respect to each input and returns to scale by fitting Cobb-Douglas production function to input output data.

(iii) In the third stage, marginal productivity of these resources are analysed.

**ADVANTAGES OF COBB-DOUGLAS PRODUCTION FUNCTION**

Following are some advantages of Cobb-Douglas production function.

(1) It is popularly used in agricultural economics research because of its simple functional form which provides for easy computations.

(2) It gives theoretically consistent and significant estimates for most of the variables used in the analysis of agricultural data.

(3) Elasticities are directly measured.

(4) The estimates of this function are mostly consistent with the principle of law of diminishing returns i.e. marginal productivity decreases as the input use increases.

(5) Returns to scale are directly estimated.

(6) The inverse relation that exist between marginal rate of substitution and factor proportions is easily computed from Cobb-Douglas function.
LIMITATIONS OF COBB-DOUGLAS PRODUCTION FUNCTION

The main critics of the Cobb-Douglas production function are K.J. Arrow, H.B. Chenery, B.S. Minhas and R.M. Solow. The critics have pointed out the following as points of criticism in the Cobb-Douglas function.

1. The Cobb-Douglas production function includes only two factors inputs i.e. Capital and Labour, where as other factors are equally important in the production process.

2. All labour units are considered homogeneous which is not always true.

3. The function assumes constant returns to scale which may not be always possible. There are certain inputs of production which cannot be increased in equal proportions for example 'Entrepreneurship'.

4. The function assumes that there is perfect competition in the market and hence the equalities between the shares and the exponents 'a' and 'b' exist. But if there is monopoly and monopolistic competition, the above relationship fails to hold in the economy.

5. The function is based on industry - industry variations; but plant to plant or firm to firm variations within an industry would seem to provide a more reasonable approach.

6. As far as the measurement of labour input is concerned we may count it in number or in man hours, but it is very difficult to measure capital input due to its depreciation over a period of time.

Inspite of the above criticism, the Cobb-Douglas production function is widely used in the field of econometric research.
There are two aspects which can be considered while question of measurement of the extent to which a farmer uses new technology in cultivation is faced. The first aspect is the number of components of new technology which a farmer uses. These components are in general (i) New Crop pattern (ii) Drip and sprinklers irrigation system, (iii) New Chemical fertilizers (iv) Use of High Yielding Variety of Seeds (v) Crop protection by using chemical insecticides and pesticides, (vi) Green House (vii) Genetically Modified Seeds and (viii) Mechanisation.

The Second aspect is that, the proportion of farm area actually brought under new technology. The use may be full or partial.

The index was developed by taking above two aspects into consideration.

**ILLUSTRATION** -

Assume that K technologies at different levels of use (extent) are available. Let us suppose that N individuals were interviewed about the extent use or adoption of these K technologies.

Let us denote eij as the jth level of ith technology. These levels are described as follows:
Let us define,

\[ X_{ijl} = \begin{cases} 
1 & \text{if ith individual adopts technology } i \text{ at jth level.} \\
0 & \text{O.W. (Other wise)} 
\end{cases} 
\]

\[ i = 1 \ldots k \quad j = 0 \ldots 4 \]

Then,

\[ M_{ij} = \sum_{l=1}^{N} X_{ijl} : \text{No of individuals adopted ith technology at jth level.} \]

Obviously,

\[ m_i = \sum_{j=0}^{4} M_{ij} = N. \]

Aggregate extent use of \( i^{th} \) technology at \( j^{th} \) level by \( N \) individuals is given by \( w \) (weightage).

\[ W_{ij} = M_{ij} e_{ij} \quad i = 1 \ldots k \quad j = 0,1,2,3,4, \]

Total extent use of ith technology is given by

\[ W_i = \sum_{j=0}^{4} W_{ij} = \sum_{j=0}^{4} M_{ij} e_{ij} \quad i = 1 \ldots k \]

Thus the weight for \( i^{th} \) technology is group of \( N \) individuals is given by.

\[ W_i = W_i. \left( \sum_{i=1}^{K} w_i \right)^{-1} \quad i = 1 \ldots k \]

(W=Individual weight)
Then technology adoption index $T_I$ for $i^{th}$ individual is given by

$$T_I = \sum_{i=1}^{K} \sum_{j=0}^{4} W^{i} e_{ij} X_{ijl}$$

$l = 1 \ldots N.$

**Particular Cases**

1) If an individual does not uses any technology i.e. $X_{i0l} = 1$

   $\forall \ i = 1 \ldots k$ i.e. $ei0 = 0 \ \forall \ i$

   i.e. $T_I^I = 0 \ \forall = \forall$

   Thus an individual not adoption any technology receives the adoption index as zero.

2) If an individual uses all technologies at full extent i.e.

   $X_{il} = 1 \ \forall i = 1 \ldots k$ i.e. $e_{ii} = 1 \ \forall i$

   i.e. $T_I^I = \sum_{i=1}^{K} W^i_l = 1$

   Thus an individual using all technology at full extent receives the adoption index as 1.
APPENDIX - III

A STUDY OF ECONOMIC IMPACT OF TECHNOLOGICAL CHANGE ON AGRICULTURAL DEVELOPMENT OF AHMEDNAGAR DISTRICT.

QUESTIONNAIRE

A) PERSONAL PROFILE OF THE FARMER -

Q. 1 (i) Name :
Address :
Taluka :
Dist :
(ii) Age :
(iii) Sex : Male \(\square\) Female \(\square\)
(iv) Qualification : S.S.C. \(\square\) H.S.C. \(\square\) Graduate \(\square\)
Post Graduate \(\square\) Illiterate \(\square\)
(v) Social Category : ________________________________

B) FAMILY SIZE -

Q.2 a) How many members do you have in your family ?

<table>
<thead>
<tr>
<th>Sex</th>
<th>Children (1-18)</th>
<th>Adult (18-65)</th>
<th>Old (Not working) above 65 yrs</th>
<th>Total Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
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<td>Female</td>
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<td>Total</td>
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b) Out of the total Literate : ________________ Illiterate : ________________

C) FARM SIZE (Possession of Land) -

Q.3 How much total land (in hectares) do you posses for cultivation ____________ Acres.
Q.4 Do you possess lease hold land? If so, how many acres?
Q.5 What amount do you pay annual as lease (Batai)? Rs. ________________
Q.6 Out of your possession how much land is left uncultivated? ____________ Acres.
Q.7 What are the reasons for leaving such land uncultivated.
   (a) ________________________________
   (b) ________________________________
   (c) ________________________________
Q.8 Amount do you pay annual for the following
   a) Land revenue Rs. ________________
   b) Other cess Rs. ________________
Q.9 Type of land you have?
   a) Coarse shallow
   b) Medium black soil
   c) Deep black soil
   d) Laterite and Lateristic
   e) Reddish Brown Soil of hill Slope

D) IRRIGATION -
Q.10 Do you have your own irrigation facility?  
   Yes  No

Q.11 Type of irrigation you use?
   a) Ground Well
   b) Bore well
   c) Canal
   d) Lift irrigation

Q.12 Land irrigated with available irrigation?
   a) Full
   b) Three Fourth
   c) Half
   d) Less than half

Q.13 How much do you spend on irrigation annually?
   a) With owned irrigation facility Rs.___________
   b) Other sources __________ Rs.___________

E) TECHNOLOGY -
Q.14 If you use the following new technology give details as follows:

<table>
<thead>
<tr>
<th>Name of technique</th>
<th>Extent of land utilised (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. New Crop Pattern</td>
<td>100% 75% 50% Below 50%</td>
</tr>
<tr>
<td>b. Drip irrigation / Sprinklers</td>
<td>100% 75% 50% Below 50%</td>
</tr>
<tr>
<td>c. New Chemical Fertilizers</td>
<td>100% 75% 50% Below 50%</td>
</tr>
<tr>
<td>d. High Yielding seeds</td>
<td>100% 75% 50% Below 50%</td>
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<tr>
<td>e. Genetically modified Seeds (Gm)</td>
<td>100% 75% 50% Below 50%</td>
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<tr>
<td>f. Green house</td>
<td>100% 75% 50% Below 50%</td>
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<tr>
<td>g. Any other (Crop. Protection)</td>
<td>100% 75% 50% Below 50%</td>
</tr>
</tbody>
</table>

F) CROP PATTERN -
Q.15 Which Crop pattern you use?
   a) Single Crop.
   b) Double Crop.
   c) Multiple Crop.
Q. 16 How much of your cultivated land is covered under such pattern?
   a) Full □
   b) Three fourth. □
   c) Half □
   d) Less than half □

G) FERTILIZERS MANURE AND ITS COSTS -
Q. 17 How much Farm side Manure you use annually.
   Number of Carts. ___________________
   Rate per Cart Rs. _______________
   Total Cost Rs. _______________

Q. 18 If you use new Fertilizers, give details.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Names of Fertilizer</th>
<th>Name of Crop</th>
<th>Use of Fertilizer in KG</th>
<th>Cost of in Rs.</th>
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Q. 19 How much of your cultivated area is covered under the use of these Fertilizers?
   a) Full □
   b) Three Fourth □
   c) Half □
   d) Less than half □

H) USE OF SEEDS AND COST -
Q. 20 Which seeds you use?
   a) Traditional (Farm produced) □
   b) Hybrid / High Yielding variety Seeds □

Q.21 Give details of use of seeds on your farm:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Names of Seed</th>
<th>Area sown</th>
<th>Use of seeds in kg</th>
<th>Cost in Rs.</th>
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</table>
Q. 22 Area covered under use of Traditional / H.Y.V. seeds.
   a) Full
   b) Three Fourth
   c) Half
   d) Less than half

I) CROP PROTECTION AND ITS COSTS -
Q.23 Which of the following methods of crop protection you use?
   a) Traditional
   b) New Chemical Pesticides / Sprays
   c) Mixed methods

Q. 24 Give details of Pesticides / Sprays you use.
   (a)
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Pesticides</th>
<th>Crop Area (ha)</th>
<th>Pesticide used Kg.</th>
<th>Pesticide used Ltr.</th>
<th>Cost in Rs.</th>
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   (b) How much is the estimated crop damage done by pests and rodents?
   Quantity ________________________ Cost Rs. ________________

Q. 25 Land covered under the use of such pesticide?
   a) Full
   b) Three Fourth
   c) Half
   d) Less than half

J) FARM MECHANIZATION -
Q. 26 Give details of Machines you use for farming?
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Names of Machines</th>
<th>Cost of Maintenance (If owned) Rs.</th>
<th>Cost of Hire if Hired Rs.</th>
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450
Q. 27 How much cultivated area is covered under Mechanization?
   a) Full
   b) Three Fourth
   c) Half
   d) Less than half

K) USE OF POWER AND ITS COST -

Q. 28 Please give details of power you use on the farm?
   a) Electric motor : Unit Consumed (1 Yr) Cost Per year Rs.
   b) Diesel Engine : Fuel Consumed Cost Per year Rs.
   c) Any other source : Annual Cost Rs.

J) FARM LABOUR COST -

Q. 29 Please give details of labour you employ on your farm -

a) Family Labour -

<table>
<thead>
<tr>
<th></th>
<th>No. of Family workers</th>
<th>Working hours per day</th>
<th>Number of days per year</th>
<th>Annual Total labour Hours</th>
<th>Wages Rate per day Rs.</th>
<th>Annual labour cost Rs.</th>
</tr>
</thead>
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<tr>
<td>Male</td>
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<td>Female</td>
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b) Hired Labour -

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<thead>
<tr>
<th></th>
<th>No. of Labourers</th>
<th>Working hours per day</th>
<th>Number of days per year</th>
<th>Annual Total labour Hours</th>
<th>Wages Rate per day Rs.</th>
<th>Annual labour cost Rs.</th>
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<td>Male</td>
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c) Animal Labour -

<table>
<thead>
<tr>
<th></th>
<th>Animal Pairs</th>
<th>Labour hours per day</th>
<th>Number of days per year</th>
<th>Cost of Hire</th>
<th>Annual fodder cost in Rs.</th>
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<tr>
<td>Owned</td>
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<td>Hired Animals</td>
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<td>Total</td>
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</tbody>
</table>
M) FARM - OUTPUT - ALL CROPS (ANNUAL PRODUCTION) -

Q. 30 Give the following details of all production of your farm during this year.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Crop or Vegetable</th>
<th>Area sown in acres</th>
<th>Output in Quintals</th>
<th>Value in Rupees</th>
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<tbody>
<tr>
<td>1.</td>
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<td>Total</td>
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</table>

Q. 31 Out of your farm produce, how much is retained for your family consumption?

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Crop</th>
<th>Retained for consumption in quintal</th>
<th>Value in Rupees</th>
</tr>
</thead>
<tbody>
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<td>1.</td>
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<td>5.</td>
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<tr>
<td>Total</td>
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</table>

N) MARKETING AND STORAGE -

Q. 32 Give following details of your storage:

a) If own storage Facility - Annual Expenses Rs. ____________

b) If hired storage - Annual Expenses Rs. ____________

Q. 33 How do you sell your farm produce?

a) Self

b) Local Adatiyas

c) Market yard

Q. 34 Give details of the following expenses incurred.

a) Cartage Rs. ____________

b) Octroi Rs. ____________

c) Other charges Rs. ____________
(Coolie etc.)

O) FIXED ASSETS -

Q. 35 Give details of fixed Assets for your farming -

a) Land : In Acres _______________ Value in Rs. _______________

b) Equipment and tools.
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Value in Rupees</th>
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</thead>
<tbody>
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<tr>
<td><strong>Total</strong></td>
<td></td>
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</tbody>
</table>

**WORKING CAPITAL**

Q. 36 Give details of the capital employed for your farming.

a) Owned money Rs. __________
b) Borrowed Money Rs. __________
c) Annual interest paid on Borrowed money Rs. __________

P) **NON - FARM INCOME**

Q. 37 Please give details of your annual income other than farming.

a. By selling milk Rs. __________
b. By Wages (working outside farm) Rs. __________
c. By some trading activity (shop etc.) Rs. __________

Q. 38 Do you take benefit of various Govt. Schemes for farmers.
Please give details.

1.
2.
3.
4.
5.

Q. 39 How do you find Govt. Schemes in your farming?

a) Most beneficial __________
b) Moderately beneficial __________
c) In adequate __________
d) Not beneficial at all __________

Q. 40 Have you leased your land out?

a) No. of Acres Leased out __________

Amount of Leased Received __________
Q. 41  
A) Have you built a new house during last 10 years period?
   a) R.C.C.    Cost Rs. __________
   b) Load Bearing Cost Rs. __________
   c) Mud Built/Chappar Cost Rs. __________
   d) Farm House Cost Rs. __________

B) Which of the following things did you buy during last 10 years?
   1) Jeep / Car
   2) Motor Cycle
   3) Tractor Trolley
   4) L.P.G.
   5) Refrigerator
   6) Cooler
   7) Sofaset
   8) TV / AV
   9) Fans
   10) Telephone / Mobile
   11) Grinder Mixer

Q. 42  Do you subscribe to the following?
   1) News Paper Yes No
   2) Magazines Yes No

......
## APPENDIX - IV

### LIST OF VILLAGES SELECTED FOR SAMPLING

<table>
<thead>
<tr>
<th>IRRIGATED REGION</th>
<th>NON-IRRIGATED REGION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Taluka</td>
<td>Name of Villages</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>1) Kopargaon</td>
<td>a) Kopargaon</td>
</tr>
<tr>
<td>b) Sangvibhusar</td>
<td>b) Sangvibhusar</td>
</tr>
<tr>
<td>c) Achalgaon</td>
<td>c) Achalgaon</td>
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<tr>
<td>d) Sanwatsar</td>
<td>d) Sanwatsar</td>
</tr>
<tr>
<td>2) Rahata</td>
<td>a) Rahata</td>
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<tr>
<td>b) Astagaon</td>
<td>b) Astagaon</td>
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<tr>
<td>c) Pimpalwadi</td>
<td>c) Pimpalwadi</td>
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<td>d) Rashin</td>
<td>d) Rashin</td>
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<tr>
<td>3) Sangamner</td>
<td>a) Sangamner</td>
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<tr>
<td>b) Wadgaon pan</td>
<td>b) Wadgaon pan</td>
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<tr>
<td>c) Chapadgaon</td>
<td>c) Chapadgaon</td>
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<tr>
<td>d) Shrigonda</td>
<td>d) Shrigonda (Factory)</td>
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<td>4) Akole</td>
<td>a) Akole</td>
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<tr>
<td>b) Gardani</td>
<td>b) Gardani</td>
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<tr>
<td>c) Dhumalwadi</td>
<td>c) Dhumalwadi</td>
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<tr>
<td>d) Brahmanwada</td>
<td>d) Brahmanwada</td>
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<td>5) Rahuri</td>
<td>a) Rahuri</td>
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<tr>
<td>b) Chinchale</td>
<td>b) Chinchale</td>
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<tr>
<td>c) Karpewadi</td>
<td>c) Karpewadi</td>
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<tr>
<td>d) Wambori</td>
<td>d) Wambori</td>
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<tr>
<td>6) Newasa</td>
<td>a) Newasa</td>
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<td>b) Wadala</td>
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<td>7) Shrirampur</td>
<td>a) Belapur</td>
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<td>b) Ashoknagar</td>
<td>b) Ashoknagar</td>
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